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FERRCO ENGINEERING LIMITED

TECHNICAL AND ECONOMICAL ASSESSMENT OF HORIZONTAL CONTINUOUS CASTING OF STEEL FOR CANMET DEPARTMENT OF ENERGY, MINES AND RESOURCES, OTTAWA

PROJECT 1015-79 SEPTEMBER 1979

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TECHNICAL AND ECONOMIC ASSESSMENT OF HORIZONTAL CONTINUOUS CASTING OF STEEL

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FOR: CANMET
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MINES AND RESOURCES
OTTAWA

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INTRODUCTION

Ferrco Engineering Limited has been commissioned by CANMET (Canada Centre for Mineral and Engineering Technology) to examine the feasibility of steel manufacturing operations using horizontal casting technology.

CANMET has been working for a number of years in adapting and developing the closed head casting techniques which are widely used for non-ferrous and precious metals and cast iron, and ferrous materials. The CANMET programme has concentrated on smaller sections than currently produced in the steel industry by conventional open mould vertical continuous casting. This has complemented the work of a number of companies and organisations in Europe and North America who have been developing techniques for the horizontal casting of steel products but in a similar size range to that currently available with vertical open mould casting.

The application of these techniques and developments to steel production on an industrial basis in Canada is the subject of this study.

SUMMARY AND CONCLUSIONS

1. This study has examined the viability of low volume steel manufacturing operations utilising a new (to the steel industry) technique of closed head horizontal continuous casting for producing a semi finished product which is subsequently hot rolled or hot forged.

2. From the scope of work proposed by CANMET and the background of experience and development currently available in the horizontal casting of steel products, four steel manufacturing operations have been selected for examination and form the basis of this report.

These are for the production of:-

a) Forging quality bar stock - approximately 70,000 tons per year of 1½" to 2" section.
b) Tool steel bar stock - approximately 5,000 tons per year of ½" to 1" section.
c) Grinding balls - approximately 36,000 tons per year, 2½" to 4½" diameter.
d) Grinding balls - approximately 17,000 tons per year, 1½" to 2½" diameter.

3. Capital cost estimates have been prepared for the four manufacturing operations, which include the facilities required upstream and downstream to the horizontal casting equipment and the necessary plant services. The estimates are based on July 1979 costs and include reasonable contingency allowances. Plant location in Southern Ontario has been assumed and building construction and equipment installation costs appropriate to the area used in the capital cost estimates. Reasonable allowance

has been made in each case for design engineering, project management and site management during construction.

4. Manning schedules for hourly paid and salaried employees in production, maintenance and administration functions have been prepared and used in establishing production costs for cast bar and rolled or forged products.

5. The main financial and operating parameters for the four plants concerned, are summarized and compared in the following table:-

	Forging Quality Bar Stock	Tool Steel Bar Stock	Grinding Balls 2½"-4½" Size Range	Grinding Balls 1½"-2½" Size Range
Capital Cost ($x10^6$)	$21.40	$15.88	$14.65	$12.30
Pre Production Expense ($x10^6$)	$ 2.10	$ 1.95	$ 1.35	$ 1.05
Working Capital ($x10^6$)	$ 6.00	$ 9.00	$ 3.00	$ 1.50
Total Capital Requirement ($x10^6$)	$29.50	$26.83	$19.00	$14.85
Production Cost - Cast Bar	$175.67/t	$1.78/lb*	$190.34/t	$222.50/t
- Finished Product	$210.71/t	$2.14/lb*	$213.89/t	$262.38/t
Average Selling Price	$380.00/t	$4.00/lb*	$360.00/t	$370.00/t
Annual Production Tonnage	71,000	4,700	35,600	17,000
Total Plant Manning	80	76	79	76
Productivity - Tons/man year	888	62	451	224
Return on equity **	22%	46%	7%	-

* Mix of M2, M7 and T1 grades

** Assumed debt/equity ratio of 50:50 and interest charges at 13% per annum

6. The financial projections show that the forging quality bar stock and tool steel bar stock manufacturing plants would be viable operations. The plant for the production of the larger sizes of grinding balls although showing a small net profit would not be viable at the level of output proposed in the study. The plant for the production of the smaller size range of grinding balls would be unprofitable.

7. This study has examined four steel manufacturing operations each designed for a particular product. Significant advantage would be obtained in a plant designed to produce a combination of these products eg. forging bar stock and grinding balls or forging bar stock and tool steel bar stock. Plant equipment would be more fully utilised, productivity increased, production costs reduced, higher sales revenues generated and a generally improved financial position obtained in regard to total capital requirements and return on equity. No attempt has been made to examine and evaluate the many combinations of products and production tonnages which might be considered. The operational and financial data presented in this report is however in a format which could be used to evaluate multi product manufacturing operations.

8. At 4,700 tons per year the tool steel bar stock manufacturing operation would appear to be on quite a small scale. However in relation to annual tool steel markets (high speed and others) of 9,300 tons in Canada and 106,000 tons in the United States (see A.D. Little Inc. market outlook) this would be a significant production capability.

Historically tool steel manufacturing has developed within steel companies utilising existing equipment installed initially, and also continuing to be used, for other

purposes. The demanding applications for tool steels and their high cost has necessitated complex processing routes with close technical control over processes and practices and a high level of marketing expertise in order to establish a good reputation and sound position in a highly competitive market area.

The scope of work proposed by CANMET required examination of a manufacturing facility to produce tool steels based on a horizontal casting facility. The logistics of the processing route proposed leads to an annual production capability of approximately 5,000 tons. This would be an unrealistic market expectation for a new company located in Canada. Rather it is anticipated that tool steel production could be carried out on a smaller scale in conjunction with the manufacture of other products as discussed in (7). Alternatively horizontal casting could be installed by an existing manufacturer and used to replace a number of steps in heating, rolling, forging, inspection etc. in their current processing route with consequent savings in yield and production costs.

9. CANMET has obtained some success in horizontally casting tool steels in sections for direct application, after heat treatment and grinding, for tool manufacture. This work is not sufficiently advanced at this time to be considered as the processing route for this study. A hot working operation (in this case using twin tandem reversing mills) has consequently been included.

There is however a question as to whether the quality of a cast and rolled product will equate to that produced by the forging and rolling procedures currently used in the tool steel industry. Forge rolling mills such as those manufactured by Schloemann-Siemag Inc., Gesellschaft fur Fertigungstechnik and

und Maschinenbau AG (G.F.M.) and others appear to provide deformation characteristics similar to these forging and rolling operations and may be required as a primary breakdown mill for the as-cast product. A G.F.M. machine is used by Edgar Allen Balfour Steels Ltd., in the United Kingdom to reduce 8½" square high speed steel ingots to 2½" section thereby eliminating a number of press forging, heat treatment, machining and rolling operations. With further development, a mill of this type, used in conjunction with conventional rolling stands may find application for the section sizes produced by horizontal continuous casting.

GENERAL BACKGROUND

The horizontal or vertical closed head casting of small sections is widely practiced by non ferrous, precious metal and cast iron producers of semi finished products.

In the steel industry use of a vertical, open head, metal mould system of continuous casting has become the accepted mode of operation. The product quality improvements and significant increase in yield associated with the process has led to its replacement of the hitherto conventional ingot casting route at a rapidly accelerating rate. The process does have disadvantages however in that steelmaking practices using aluminum for deoxidation can lead to tundish nozzle blockage and that billet cleanliness problems can arise from the inclusion of reoxidation products during casting. Techniques have been and continue to be developed to nullify these effects. The process is in practice restricted to casting a minimum section of 3" x 3" because of physical limitations on the control of a free falling stream of metal into the mould cavity. Also the long strand cooling length associated with the solidification/strength characteristics of the steels concerned, necessitate tall casting machines installed in high (expensive) buildings.

Theoretically these disadvantages can be overcome with a horizontal closed head casting machine and there are a number of publicised machine designs which have adapted the techniques and equipment developed in the non ferrous field for steel applications. Basically this has involved replacing graphite used as the mould material and as the nozzle conducting liquid metal into the mould, with a ceramic sleeve/metal mould combination.

The four most significant of these steel casting designs originated with General Motors (Xtru-Cast), Davy Ashmore (HORICAST), the U.S.S.R. and the Technicon Corporation (Watts process).

The General Motors equipment was developed at a pilot plant installed in the mid '60's at the Chevrolet forging plant in Detroit, Michigan and operated as a shared venture with G.M. Research. The casting machine has intermittant withdrawal from a stationary mould containing a boron or silicon nitride nozzle ring between the mould and tundish orifice. A full scale plant based on the G.M. design of horizontal casting machine, using 'in-house' scrap to produce bar for direct application as forging stock, was started up at the G.M. Oldsmobile Division at Lansing, Michigan in 1968. 'As-cast' bar, was found to be unsuitable for some of the forging applications and this led to the installation of a 6 stand rolling mill in 1972. The plant currently has two 10 ton arc furnaces supplying three horizontal casting machines (two operating, with one on repair or standby) producing 3 1/2- 3 3/4" rounds which are normally rolled to 1½ to 2" diameter bar stock. Plant production with a 15 turn operation is approximately 50,000 tons per year. General Motors have licensed their "X tru-Cast" process on a non exclusive basis to Technica Guss, a West German company and supplier (since 1966) of horizontal casting machines and associated equipment for manufacturing brasses, bronzes, grey iron and aluminium. It is reported that one company in West Germany has installed a plant using the process and that negotiations are proceeding with a major West German automobile manufacturer for a similar application to that at G.M. Lansing.

The Davy-Ashmore machine is similar in concept to that of General Motors. Davy became interested in horizontal casting in 1967 and established a small scale pilot plant at one of its foundries in 1968. Encouraged by initial development work the machine was redesigned, strengthened to give the capability of casting up to 6" rounds or squares and moved to another foundry within the Group at Jarrow in England. Development work on the process continued and Davy/Loewy entered into a licensing arangement for the process with Nippon Kokan (N.K.K.) in 1977. An agreement has been made between the two companies to conduct a joint programme aimed at the industrialisation of the process which has been given the trade name "HORICAST". N.K.K. commissioned a horizontal casting unit at its Fukuyama Works in February 1979 which is now running on a continuous basis, producing carbon steel billets 3"-6" in section.

The Russian version of continuous casting is close to conventional strand casting design in that continuous withdrawal from a reciprocating mould is practiced, with an unidentified ceramic sealing the mould to the tundish. Thus the entire mould/tundish assembly is oscillated. Danielli of Italy has a licensing arrangement with Licensintorg and is presently building two machines in Italy.

The revolutionary Watts process, although not strictly continuous, uses a "closed end" mould system in which the mould and tundish are continuously separating from each other leaving the casting behind. The pilot machine was built by the Technicon Corporation (in whom the patents are vested) at Plymouth, Pennsylvania, to cast 4" square billets up to 16 foot long. Although a wide range of steel grades has been cast experimentally and apparently successfully, the process does not appear to have found commercial application.

A comparison of the mould/tundish designs for these four processes together with associated production data is shown in Figs. 1 and 2 in the Appendix to this report.

In an independant development, as an offshoot to the General Motors work, Lakehead Alloys was established at Duluth, Minnesota in the early 70's. The plant produced bar stock for forgings and for grinding ball manufacture. Plant equipment included a ball forging machine directly fed from the horizontal casting machine. Although not now functioning the operation was considered to be viable. One of the principles in Lakehead Alloys has since established Advanced Concast Engineering Inc. in California to manufacture custom horizontal continuous casting equipment. The company has built two machines. One for the Stoody Co., casts Cobalt based hard facing rod from 3/16 - 3/8" diameter. The second machine is used by Advanced Concast Engineering as a production tool and experimental vehicle. The company reports the ability to cast carbon and low and high alloy steels from 3/16" diameter rod to 3 3/4" bars.

With the exception of the Advance Concast Engineering development work, the four systems described previously have been applied to the production of round or square billets within 3" to 6" section size, at speeds somewhat less than those obtained in conventional strand casting. In contrast to these processes the CANMET development work on closed-head steel casting has been directed towards establishing techniques for casting less than conventionally sized products ie. section sizes in the range 0.5" to 1.5", for use in the as-cast condition or with some subsequent working. Casting trials were originally

carried out on an existing vertical closed head casting machine modified for steel casting. In more recent years, a custom built horizontal casting machine has been used to produce low alloy, tool and stainless steels. Progress in this development work has been reported in a number of CANMET publications and technical presentations.

As an adjunct to this development work, Ferrco Engineering Limited has been commissioned by CANMET to examine steel manufacturing operations utilising horizontal casting techniques by:-

1) Establishing capital, operating and maintenance costs for casting units operated as single or multiple strands.
2) Establishing complete capital and operating costs on facilities and equipment, upstream (furnaces etc.) and downstream (rolling mill stands etc.) from a horizontal caster producing from 1" to 4" diameter bar.
3) Identifying production costs of (a) cast and (b) rolled bar in terms of $/ton and productivity in terms of tons/man/year for various levels of production.
4) Identifying both products and markets to which horizontal casting technology could be applied on a commercial basis.

On consideration of the foregoing scope of work and the background of experience and development currently available in the horizontal casting of steel products, four steel

manufacturing operations have been selected for examination which form the basis of this report. These are for the production of:-

1) Approximately 70,000 tons per year of forging quality bar stock in a size range of 1½" to 2" section.
2) Approximately 5,000 tons per year of tool steel bar stock in a size range of ½" to 1" section.
3) Approximately 36,000 tons per year of steel grinding balls, 2½" to 4½" in diameter.
4) Approximately 17,000 tons per year of steel grinding balls, 1½" to 2½" in diameter.

When possible plant configurations were being examined for this study, there was only one publicised supplier of horizontal casting machines designed for steel production on an industrial basis. This was the West German company Technica Guss which manufactures the General Motors "X-tru Cast" process equipment under license. The capital cost estimates and equipment layouts in this study reflect use of this equipment. More recent information indicates that Davy Loewy in the United Kingdom, its Japanese license N.K.K. and Advanced Concast Engineering Ltd. in the United States are now also suppliers of horizontal casting equipment for steel products.

HORIZONTAL CONTINUOUS CASTING

COMMERCIAL FEASIBILITY AND MARKET OUTLOOK

Report to

Ferrco Engineering Limited

August, 1979

Arthur D Little Inc

HORIZONTAL CONTINUOUS CASTING

I. Summary

The horizontal casting technology as applied to steel could find applications in the following situations:

1. Replacement of ingot casting in specialty steel mills;
2. Production of raw materials for forging
   a. In small markets remote from existing steel plants;
   b. In captive plant situations, particularly where internally-generated scrap is available.

All of the significant prospective uses require that the cast bars or billets produced are suitable for further hot working in facilities which are economic at a relatively small scale of operation. In particular, production of tool steel bars and of forged products appear to be the main areas of potential application. In the former, the cast billet must be as suitable for further hot rolling as a rolled or cogged billet, and in the latter, it must be as suitable for forging as a hot-rolled bar.

From a market standpoint it appears that the best potential exists in captive rather than market-oriented situations. In particular, companies producing up to 50,000 tons per year of small forgings with access to suitable scrap metal supplies would appear to have a significant economic incentive to manufacture their own raw materials rather than purchase them from a steel mill as a hot-rolled bar, assuming that the cast product is a suitable substitute material.

II. Potential Roles for Horizontal Casting

Horizontal continuous casting is a process for converting liquid metals to solid metals of controlled size and cross section. Other methods which are currently in use for this step of the steel manufacturing process are ingot casting and vertical continuous, or strand, casting.

According to information provided by Ferrco Engineering, Ltd., a single horizontal casting machine can produce from about 0.5 tonnes per hour to about 7.5 tonnes per hour, depending on the product size and the number of strands (one or two). Strand casters for billets normally produce much larger quantities (30-90 tonnes per hour), while ingot pouring can be used at virtually any scale. Ingot pouring produces a product which requires more work to convert to a finished steel product than the billets or bars produced by continuous casting machines, but products from continuous casting machines will also require some hot mechanical working in order to be made suitable for use. In other words, the output of a horizontal continuous casting machine would be a semi-finished product which will require rolling, forging, extrusion, or similar processing for conversion into useful final products.

In considering potential uses for horizontal casting of steel, one of the most important factors is that the scale or capacity of the casting machine must match the scale or capacity of both the melting unit which feeds it and processing units which take the casting machine's output and convert it to useable products. This is particularly important because the casting processes now in use (ingot or strand casting) represent small proportions of both the capital investment and operating costs of steel mill operations. In general, investment in the casting step represents under 7% of total plant investment, and the operating costs of casting represent under 5% of the total manufacturing costs of finished steel products produced. Thus, a saving in the casting step in either capital or operating costs will represent only a small improvement in the overall operation, but any inefficiencies caused in either the upstream or downstream operations could have a major impact on the viability of the entire operation.

Within the steel and related industries we see only a few potential opportunities for the adoption of horizontal continuous casting, even if we make the assumption that the product produced by such a machine is suitable as a substitute for ingots, cast, rolled or cogged billets, or hot-rolled bars (in selected uses only). The potential applications rest on the following assumptions:

1. Horizontal casting might decrease costs and improve yields compared to ingot pouring in highly-specialized, low-volume but high-priced steel product manufacturing operations;

2. Horizontal casting could be matched with melting and processing equipment of like capacity in remote locations;

3. Horizontal casting could be matched with melting and processing equipment of like capacity in situations where improvements in the utilization of internal scrap could be realized, or where outside scrap is readily available at favorable prices.

In considering these postulations, we are led to the following specific situations where the use of horizontal continuous casting might possibly be justified:

1. Tool steel production;

2. Forged grinding ball production at or near remote mining sites;

3. Forging billet or bar production in plants with excess captive scrap, or in areas where scrap is readily available at favorable prices.

III. Markets Associated with Potential Horizontal Casting Applications

A. Tool Steels

The production and sales of tool steels occupy a small and specialized niche in the steel business. Tool steel products are characterized by extreme need for high and uniform quality and excellent performance under extremely difficult conditions. Consequently, many specialized types of equipment are used in their production, extensive inspection and quality control procedures are necessary, and the prices of these products range from seven to ten times as much as conventional steel products. The markets for tool steels are relatively small and specialized, and a limited number of producers operate in this portion of the steel business.

In Canada, there is one producer of tool steel--Atlas Steels at Welland, Ontario. In the United States, there are approximately ten producers, as shown in Table 1.

The volume of tool steel sales in Canada is not disclosed since there is only one producer. We estimate, however, that the total market in Canada for carbon, alloy, and high-speed tool steel bars is about 9,300 tonnes per year, of which nearly half is imported from outside countries. From import statistics and our own estimates, we believe that annual consumption of tool steel in Canada is broken down about as follows:

High Speed	1,300 tonnes
Carbon Tool Steel Bars	1,000 tonnes
Alloy Tool Steel Bars	6,000 tonnes
Other Tool Steels (forgings, sheet, plate, die, etc.)	1,000 tonnes
TOTAL	9,300 tonnes

In the United States, total domestic shipments of tool steels are reported to be about 80,000 tonnes and imports have been about 30,000 tonnes and exports about 5,000 tonnes. Estimated breakdown by grade in the United States is as follows:

High Speed	15,000 tonnes
Carbon Tool Steel	15,000 tonnes
Alloy Tool Steel	62,000 tonnes
Special Grades and Products	14,000 tonnes
TOTAL	106,000 tonnes

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TABLE 1

TOOL STEEL PRODUCERS

Canada	
Atlas Steels	Welland, Ontario
United States	
Al Tech Specialty Steel Co.	Dunkirk, New York
	Watervliet, New York
Bethlehem Steel Co.	Bethlehem, Pennsylvania
Braeburn Alloy Steel Division	Braeburn, Pennsylvania
Carpenter Steel Division	Reading, Pennsylvania
Crucible, Inc.	Syracuse, New York
Universal-Cyclops Specialty Steel	Bridgeville, Pennsylvania
Guterl Specialty Steel	Lockport, New York
Teledyne-Vasco	Latrobe, Pennsylvania
Latrobe Steel	Latrobe, Pennsylvania

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The markets for tool steels in both Canada and the United States are adequately supplied by the North American and overseas producers. Consumption of tool steels, which is highly concentrated in the heavily industrialized areas of the United States (Great Lakes area) and Canada (southern Ontario), is not expected to grow at more than 1.5% to 2.0% per year. Existing capacity is more than adequate.

From a commercial standpoint, the horizontal casting concept is not of sufficient importance in the overall business to be the basis for a new venture in the tool steel business. If horizontal casting is technically suitable for the production of semi-finished tool steel billets and could replace the ingot casting and primary rolling or cogging steps with cost savings and improved material yield, it could be of interest to an existing tool steel producer. It must be emphasized that in tool steel production quality and consistency is absolutely critical. Therefore, it must be established beyond doubt that this production system will work before any producers might be willing to seriously consider installation of such a unit.

We believe that the best opportunity for adoption of horizontal continuous casting is probably in an existing tool steel plant because of the critical importance of the market penetration in this business. However, the parameters of the study required the economic analysis of a complete plant, including melting and rolling, and this was done for a facility of roughly 5,000 tons per year capacity.

B. Grinding Balls

Grinding balls are used in the grinding of iron and non-ferrous metal ores, of cement clinker, and other miscellaneous mineral products. They may be made in two ways--by casting of molten metal (high-nickel irons, white irons or steel) into molds, or--much more commonly--forging of high carbon or alloy steel bars into balls followed, in some cases, by heat treatment.

Much of the consumption of grinding balls occurs in locations remote from steel mills and the shipping distances are quite long. In Canada, the major grinding ball consuming areas are the Labrador and Quebec iron ranges and the Sudbury and British Columbia non-ferrous mining areas. Total consumption of grinding balls and cast iron slugs or billets is in the neighborhood of 70,000 tonnes per year in Canada.

In the United States major consumption is in the Lake Superior iron range and in the Rocky Mountain non-ferrous mining area. The total consumption of grinding balls in the United States is estimated to be about 200,000 tonnes per year.

In the United States, according to an extensive survey of grinding media use which was recently done by the Reserve Mining Company, the iron ore industry consumed 46% of all grinding balls used in the mining industry while copper companies consumed 52%. In fact, a small but significant consumption outside the mining industry for grinding of cement, pigment materials, etc., would reduce these figures if compared to the total instead of only the mining industry use.

Six taconite iron ore producers in Minnesota accounted for 70% of the grinding ball use in the iron ore industry, or about 28% of total grinding ball use. The main suppliers to this industry include Algoma Steel in Sault Ste. Marie, North Star Steel in Duluth, and Armco Steel in Kansas City, Missouri. A list of grinding ball producers is shown in Table 2.

In Canada, the iron ore industry accounts for only about 10% of grinding ball (including cast slugs, etc.), consumption, whereas the copper mining industry represents about 55%. The balance is consumed in other non-ferrous ore milling, including molybdenum, lead, zinc, nickel, and uranium. Thus, the Quebec-Labrador iron range, which accounts for about 80% of Canadian iron ore production, is estimated to require about 6,000 tonnes per year of grinding balls. The British Columbia copper industry is estimated to use about 15,000 tonnes per year, and the Ontario iron ore and non-ferrous milling business nearly 40,000 tonnes.

Producing points for grinding balls, as shown in Table 2, are spread across Canada from Vancouver to Noranda. However, the main production of forged balls is at the steel mills of Ontario and forged grinding balls which are used in Labrador and Eastern Quebec must be shipped from southern Ontario.

The minimum economic size of a grinding ball manufacturing plant is determined by the ball-forging machine capacity. For a plant producing small diameter balls the minimum economic size is about 17,000 tons per year, and for a plant producing large diameter balls, it is about 35,000 tons per year. Plants in these size ranges have been examined in this study.

C. <u>In-Plant Use--Forgings</u>

The final possible use for the horizontal casting technology which is being considered involves the internal production of cast forging bars or billets by a company which generates substantial quantities of internal scrap. Generally, companies producing automobiles, agricultural equipment, and related products generate substantial quantities of scrap iron and steel in the manufacturing process. It is not uncommon for such companies to utilize a portion of this scrap in their own foundry operations, but due to the high investment and large scale involved in steel bar production, few companies have used this scrap to produce steel bars for themselves. It is possible that by using the horizontal casting technology a manufacturer could internally recycle scrap which would otherwise be sold to scrap dealers (or recycle some scrap and purchase some from outside) and avoid the purchase of a similar quantity of steel bars from steel mills.

TABLE 2

GRINDING BALL PRODUCERS

Canada			
Algoma Steel Co.	Sault Ste. Marie, Ontario	Forged	
Burlington Steel Co.	Hamilton, Ontario	Forged	
Stelco	Edmonton, Alberta	Forged	
	Gananoque, Ontario	Forged	
Neilson Steel	Sudbury, Ontario	Cast	Not Now in business
Ocean Foundries	Vancouver, British Colombia	Cast	
Quebec Iron Foundry	Mississauga, Ontario	Cast	
	Noranda, Quebec	Cast	
Wabi Iron Works	New Liskeard, Ontario	Cast	
United States (Forged Only)			
Armco Steel Co.	Kansas City, Missouri		
CF&I Steel Corp.	Pueblo, Colorado		
North Star Steel	Duluth, Minnesota		
Pacific States Steel	Union City, California		
U.S. Steel	Johnstown, Pennsylvania		
Coates Steel Product	Greenville, Illinois		

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In Canada, it appears that the best opportunities for such an operation would exist in three industries--automotive, agricultural equipment, and construction and mining equipment. Each of these is an important consumer of hot-rolled steel bars, and each has several major plants where the use of this technology could be of interest.

In the United States, the opportunities would be broader. In addition to more plants in the three industries listed above, there could be opportunities in the oil and gas equipment industry and the industrial equipment industries.

We would estimate that at an annual output of 5,000 to 10,000 tons there might be five to ten companies in Canada which could be candidates for this process, while in the United States this number might be as high as 50 to 75. As the unit size of the horizontal casting facility increases, however, the number of potential candidates for its use declines, and there are very few candidates who would be capable of using over 50,000 tons per year.

FINANCIAL PROJECTIONS

1. PROJECTED BALANCE SHEETS

	Forging Bar Stock	Tool Steel Bar Stock	Grinding Balls large	Grinding Balls small
	$'000	$'000	$'000	$'000
		A S S E T S		
Working Capital	6,000	9,000	3,000	1,500
Pre-Production Expense	2,100	1,950	1,350	1,050
Capital Cost	21,400	15,879	14,650	12,300
	29,500	26,829	19,000	14,850
		LIABILITIES AND EQUITY		
Current & Long-Term Debt	14,500	12,829	9,000	6,850
Equity	15,000	14,000	10,000	8,000
	29,500	26,829	19,000	14,850

A Debt equity ratio of approximately 50:50 has been assumed and interest charges have been calculated at 13% per annum.

The Working Capital and Pre-Production Expenses are estimates based on experience.

2. PROJECTED INCOME STATEMENTS

	Forging Bar Stock	Tool Steel Bar Stock				Grinding Balls	
		M2 Grade	M7 Grade	T1 Grade	Total	large	small
Sales - Tons	71,000	1,567	1,567	1,566	4,700	35,600	17,000
Selling Price per Net Ton	$380.00	$6,930	$6,030	$11,016	-	$360.00	$370.00
Cost of Sales per Net Ton	$210.71	$3,648.92	$2,830.52	$6,383.58	-	$213.89	$262.38
	$'000	$'000	$'000	$'000	$'000	$'000	$'000
Sales	26,980	10,859	9,449	17,251	37,559	12,816	6,290
Cost of Sales	14,960	5,718	4,420	9,997	20,135	7,614	4,460
	12,020	5,141	5,029	7,254	17,424	5,202	1,830
Expenses							
Overhead & Administration	662				665	637	637
Depreciation	2,185				1,648	1,490	1,235
Amortization of Pre-Production Expenses	700				650	450	350
Interest on Debt	1,885				1,668	1,170	890
Total Expenses	5,432				4,631	3,747	3,112
Net Profit before Income Taxes	6,588				12,793	1,455	(1,282)
Estimated Income Taxes	3,294				6,396	727	-
Net Profit for Year	3,294				6,397	728	(1,282)

Depreciation has been calculated at a straight line basis at 10% per annum for equipment and 5% per annum on buildings.

Pre-Production Interest has been capitalized and included in the Equipment Depreciation at 10% per annum. The balance of Pre-Production Expenses has been shown as an expense in 1 year.

Corporation Income Taxes have been calculated at 50%.

The Return on Equity for the Forging Bar Stock is 22%; for the Large Grinding Balls it is 7%; and for Tool Steel Bar Stock is 46%.

PLANTS UNDER CONSIDERATION

Section 1 - Forging Quality Bar Stock Production

- Approximately 71,000 tons per year of 1½" to 2" section

1.1 PLANT PARAMETERS

(1) AT CASTING MACHINE

Assume cast bar for rerolling is 3-4" round averaging 3½" round.
Anticipated average casting rate 7 tph/strand.

Assume 95% availability at casting machines
overall casting rate = 7x.95 = 6.7 tph

Have 5760 hrs available
Annual tonnage/strand = 5760 x6.7 = 38,600 tons/year

Assume have two casting machines available
each single stranded (+1 machine on standby/repair)

Annual cast bar tonnage = 2x38,600 = 77,200 tons

(2) AT ROLLING MILL

Assume mill yield = 92%
Annual finished product capability = 77,200x.92
= 71,000 tons

6 stand mill accepting 3-4" rounds and producing 1½-2" rounds.

(3) AT MELTING UNIT

Casting 77,200 tons/year of bar stock for rerolling.

Assume liquid metal/cast bar yield = 97%
Require $\frac{77,200}{0.97}$ = 79,600 tons/year liquid metal

Have 5760 hrs./year available

Anticipated melting efficiency (availability) = 90%
Available hours = 5760x0.9 = 5184 hours

Melting Rate Required = $\frac{79,600}{5184}$ = 15.4 tph liquid metal

Assume 90 minute heat cycle
Need $\frac{15.4}{60}$ x 90 = 23.1 ton heat size

1.2 PLANT DESCRIPTION (see drawing MA004370 in the Appendix)

1. Site and Services

A 10 acre site of reasonable terrain has been anticipated with adequate power supply and water of sufficient quantity and suitable quality available at the site boundary. Reasonable access to rail and road services has been assumed.

The capital budget estimate anticipates that the plant will be serviced by a single 46kv line to a main switchyard where appropriate transformation and switching equipment for arc furnace power supply and plant distribution systems will be installed.

A combined recirculating process water system for both equipment and product cooling is provided. Equipment cooling water (arc furnace - including water cooled panels, transformer, casting machine moulds, induction heating units, rolling mill motors etc.) together with contact water from mill roll cooling and mill flume scale flushing will be fed to a primary settling pit. It will be pumped to a thickener/ clarifier to further reduce scale levels and collected in a hot well. The process water will then be pumped over open evaporative type water cooling tower cells to a cool

well from which it is recirculated through the system. Losses in the process water system, through evaporation, blowdown etc. will be replaced by treated potable water. The pumping equipment for the system will be installed in a pumphouse, with the hot and cool wells also located in the building. Equipment for the plant compressed air system is also installed in the pumphouse

Plant potable water and sanitary systems are provided. A plant fire protection system supplied from the potable water system is also included.

A natural gas distribution system for the reheat/ holding furnace, ladle and tundish heating, plant heating and miscellaneous service drops is included. A back up fuel oil system (#2 fuel oil) for the reheat furnace, including a short term oil storage tank, is also provided.

Oxygen will be distributed from a single storage tank (provided by others) to the arc furnace mezzanine and miscellaneous service drops.

2. Plant Equipment and Process Description

Prepared scrap delivered by rail car to the melt shop will be transferred by a magnet equipped 35/10t overhead

crane to a 500 cu.ft. capacity scrap bucket located on an automatic weigh scale. The scrap is then transferred via scrap bucket by the melt shop crane to a single 12ft. diameter electric arc furnace fitted with water cooled panels and located on a 24 ft. high mezzanine. The furnace is powered by a 25 MVA transformer and is capable of producing approximately 23 ton heats in 90 minutes tap to tap time.

Furnace fume emissions are contained by direct evacuation through the furnace roof combined with a hood collection system over the furnace and tapping spout. The fume is ducted to a reverse flow pre-sure type baghouse of 200,000 scfm capacity.

The arc furnace taps into a 40 ton capacity ladle which is suitably designed to provide a continuous supply of liquid steel to the tundishes. The ladle sits on a ladle carriage which moves on rail tracks over the tundishes of three horizontal casting machines of proprietary design. The plant is laid out for two machines operating at any one time with the third machine on repair or standby. Tundish capacity is approximately 3000lbs. of liquid steel. The machines are designed to operate continuously for approximately 24 hours with the liquid steel level in the tundishes topped up from the ladle when required.

Each casting machine has a withdrawal unit and pendulum type hydraulic shear in line where the bars of 3"-4" section are cut to approx. 10 ft. lengths. They pass via runout tables and a cross transfer table to the entry

of a gas fired holding/reheat furnace. Normal operating practice will be to direct charge the as-cast bars to the walking beam furnace for temperature equalization and preheating to 1650°F. The bars will then be brought up to rolling temperature by a 1000 KW 300 HZ, 3 coil induction heating unit located in line with the rolling mill.

Laydown space is provided in the vicinity of the holding/reheat furnace to accommodate cast bars produced during periods of mill downtime. The furnace is designed to preheat these cold bars to 1650°F at a rate of 15 tons per hour with subsequent induction heating to rolling temperature during periods of melt shop down time or when otherwise required.

Following induction heating the bars enter a 6 stand rolling mill of VHVHVH configuration with 16" vertical stands and 14" horizontal stands. Each stand has a 150 H.P. D.C. drive. Bars, rolled to 1½"-2" rounds, are conveyed to a 48' by 24ft. rake type cooling bed with chain type discharge to cradles and manual bundling. Bundles will be cut to ordered length by cold saw and then transferred to

storage prior to truck shipment.

3. Buildings

The melting and casting facilities are housed in a 60 ft. x 165ft. bay serviced by a 35/10t E.O.T. crane. Provision has been made in the layout for alloy storage and charging facilities peripheral furnace equipment on the furnace mezzanine floor and for ladle and tundish repair and preheat facilities. A lean-to annex to the melt shop is provided for refractory storage.

The rolling mill and finishing facilities from the exit of the casting machine to product storage and shipment are housed in a 65ft. x 300ft. bay serviced by two 5 ton E.O.T. cranes. A combination maintenance and repair shop with roll storage and roll preparation facilities is also located in the bay. Provision has been made in the layout for the storage of in-process material and finished products.

1.3 MANNING SCHEDULES

Plant Manning Summary

	Days Only	Shift	Total
Salaried Employees	18	-	18
Hourly Paid Employees	7	55	62
Total	25	55	80

Plant Manning

a) Salaried Employees

Plant Manager	1
Secretary/Receptionist	1
Melting/Casting Foreman	1
Roller	1
Maintenance General Foreman	1
Purchasing Manager	1
Safety/Personnel Manager	1
Industrial Nurse	1
Clerk/Typist	1
Janitor	1
Accountant	1
Payroll/Billing Clerk	1
Accounts Receivable/Payable Clerk	1
Shipper	1
Shipping/Finishing Foreman	1
Clerk/Typist (Shipping)	1
Sales Manager	1
Salesman	1
	18

b) Hourly Paid Employees - 3 Shift Working

	Per Shift	3 Shift Operation	Days Only
Raw Material Handling			
Crane Operator	1	3	
Labourer	1	3	
Melting (one furnace)			
Lead Hand/First Helper	1	3	
2nd Helper	1	3	
Stocker	1	3	
Ladleman	1	3	
Casting (two machines operating)			
Machine Operators	2	6	
Helper	1	3	
Reheating and Rolling			
Assistant Roller	1	3	
Millman	1	3	
Crane Operator	1	3	
Finishing Lead Hand	1	3	
Labourer	1	3	
Shipping			2
Roll Turning			1
Maintenance			
Refractory Repairman	1	2	
Refractory Labourer	1	2	(2 shift operation)
Casting Machine set up			1

Maintenance Cont'd			
Millwright	1	3	
Electrician	1	3	
Welder			1
Machinist			1
Quality Control			
Shift Chemist	1	3	
Lab Technician			1
Total		55	7

1.4 MISCELLANEOUS DEPARTMENTAL COSTS

Melt Shop Labour

Salaried Employees (1)	42,000
Hourly Paid Employees (27)	540,000
	$582,000

Rolling Mill Labour

Salaried Employees (4)	104,000
Hourly Paid Employees (18)	360,000
	$464,000

MAINTENANCE EXPENSES

Salaried Employees (1)	$42,000
Hourly paid employees (13)	260,000
Repair & Maintenance Materials @ 3$/ton	210,000
	$512,000

Allocation

55% Melt Shop	40% Rolling Mill	5% Admin.
$282,000	$205,000	$25,000

Quality Control Expenses

Hourly paid employees (4)	$80,000
Supplies	30,000
	$110,000

Allocation

75% Melt Shop	25% Rolling Mill
$83,000	$27,000

PLANT ADMINISTRATION COST

Salaries including benefits at 20%	$322,000
Provision for directors fees and expenses	10,000
Public relations	5,000
Travel & entertainment & auto rental	25,000
Advertising	10,000
Equipment Rentals	10,000
Auditing Costs	10,000
Donations, subscriptions & dues	5,000
Legal and professional fees	20,000
Stationary and postage	5,000
Provision for doubtful accounts	15,000
Miscellaneous supplies and services	10,000
Maintenance, labour, supervision, supplies and tools	25,000
Personnel supplies and safety supplies	20,000
Water	10,000
Insurance	25,000
Demurrage	25,000
Taxes	100,000
Consulting fees	10,000
	$662,000

1.5 OPERATING COSTS

Estimated Operating costs for Conversion to Cast Bar and Rolled Bar Product - C1050 Grade Assumed

1. Per ton of cast bar 77,200 tons per year

Yield scrap/cast bar 90.2%

Scrap 1.109 tons @ 100 $/ton	$110.90
Less returns(0.05)tons @ 90$)	4.50
Net scrap cost	106.40
Additives & Alloys	10.54
Fluxes	3.43
	120.37
Supervision and Labour	7.54
Electrodes	13.19
Power	13.32
Refractories	11.63
Oxygen	0.73
Fuel	1.31
Supplies & Outside Services	1.85
Slag disposal (allowance)	1.00
Quality Control	1.08
Maintenance	3.65
Cast Bar Production Cost	$175.67

2. Per Ton of Rolled Bar (71,000 tons per year)

Yield cast bar to finished product 92.0%

Cost of cast bars produced	$175.67
Cost @ 92% yield	$190.95
Less scrap credit 6% @ $90.00/ton	5.40
Net cast bar cost per ton of finished product	$185.55
Supervision and Labour	6.54
Power	3.75
Fuels & Refractories	6.90
General Supplies	1.45
Rolls and Guides	3.25
Quality Control	0.38
Maintenance	2.89
Total cost per ton of finished product	$210.71

1.6 CAPITAL COST ESTIMATE

CAPITAL BUDGET ESTIMATE SUMMARY

		$
1.	Site	381,000
2.	Utilities	3,010,000
3.	Melting & Casting	8,157,000
4.	Rolling & Finishing	7,160,000
5.	Ancillaries	244,000
6.	Spare Parts	540,000
7.	Engineering, Project Management & Other Professional Services	1,882,000
		21,374,000

CAPITAL COST ESTIMATE

		$	$
1.	**Site**		
	1.1 Permits & Surveys	10,000	
	1.2 Site Preparation	33,000	
	1.3 Transporation and Site Work	226,000	
	1.4 Storm Drainage	12,000	
	1.5 Site Purchase - allowance	100,000	
	TOTAL		381,000
2.	**Utilities**		
	2.1 Process Water System	1,071,000	
	2.2 Potable Water	51,000	
	2.3 Fuels and Oxygen	196,000	
	2.4 Sanitary System	71,000	
	2.5 Electrical Services	1,424,000	
	2.6 Compressed Air	111,000	
	2.7 Service Building		
	- Pumps and compressors	86,000	
	TOTAL		3,010,000
3.	**Melt Shop**		
	3.1 Scrap Handling	487,000	
	3.2 Melting	2,257,000	
	3.3 Additive & Refractory Systems	279,000	
	3.4 Casting	2,092,000	
	3.5 Air Pollution Control	2,057,000	
	3.6 Melt Shop Crane	302,000	
	3.7 Melt Shop Buildings	683,000	
	TOTAL		8,157,000

		$	$
4.	Rolling Mill		
	4.1 Reheating Systems	1,323,000	
	4.2 Rolling Mill	3,461,000	
	4.3 Product Handling	684,000	
	4.4 Quality Control & Roll Shop	702,000	
	4.5 Mill Cranes	257,000	
	4.6 Mill Building	733,000	
	TOTAL		7,160,000
5.	Ancillaries		
	5.1 Maintenance & Stores Equipment	60,000	
	5.2 Main Offices & Change House	184,000	
	TOTAL		244,000
6.	Spare Parts Allowance		
	5% of Equipment Cost		540,000
7.	Engineering, Project Management & Other Professional Services		
	10 % of capital cost with site purchase cost and spare parts allowance excluded		1,882,000

PLANTS UNDER CONSIDERATION

SECTION 2 - Tool Steel bar stock production
- approximately 5,000 tons per year of ½" to 1" section

2.1 PLANT PARAMETERS

(1) AT CASTING MACHINE

Assume casting 1½" - 2½" round/square average 2" round/square to be then hot rolled to ½ - 1½ round/square etc.

Anticipated average casting rate = 1.2 tph/strand

Assume 95% availability at casting machine
Actual casting rate = 1.2 x 0.95 = 1.10 tph/strand

Have 5760 hrs./year available
Actual tonnage/strand = 5,760 x 1.10
= 6,300 tons

Assume have one casting machine available
- single stand (+1 machine on standby/repair)

Annual casting capability = 6,300 tons

(2) AT ROLLING MILL

At 75% overall yield on the mill, would have 6,3000 x .75 = 4,700 tpy of tool stock ½ - 1" rounds/squares or otherwise for sale.

(3) AT MELTING UNIT

Casting 6,300 tpy of bar stock for re-rolling

Assume liquid metal/cast good bar yield - 94%
Require $\frac{6,300}{.94}$ = 6,700 tons / year of liquid metal

Have 5760 hrs./year available

Anticipated melting efficiency (availability) = 90%
Available hours = 5,760 x 0.9 = 5,184 hours

Melting rate required = $\frac{6,700}{5,184}$ = 1.30 tph liquid metal

Assume 180 minute heat cycle
Need 3 x 1.30 = 3.9 ton heat size (liquid metal)

2.2 PLANT DESCRIPTION (see Drawing MA004371 in the Appendix)

1. Site and Services

A 5 acre site of reasonable terrain has been anticipated with adequate power supply and water of sufficient quantity and suitable quality available at the site boundary.

The capital budget estimate anticipates that the plant will be serviced by a single 46kv line to a main switchyard where appropriate transformation and switching equipment for arc furnace power supply and plant distribution systems will be installed.

A combined recirculating process water system for both equipment and product cooling is provided. Equipment cooling water (arc furnace - including water cooled panels, transformer, casting machine moulds, induction heating units, rolling mill motors etc.) together with contact water from mill roll cooling and mill flume scale flushing will be fed to a primary settling pit. It will be pumped to a thickener/ clarifier to further reduce scale levels and collected in a hot well. The process water will then be pumped over open evaporative type water cooling tower cells to a cool

well from which it is recirculated through the system. Losses in the process water system, through evaporation, blowdown etc. will be replaced by treated potable water. The pumping equipment for the system will be installed in a pumphouse, with the hot and cool wells also located in the building. Equipment for a plant compressed air system will also be installed in the pumphouse.

Plant potable water and sanitary systems are provided. A plant fire protection system supplied from the potable water system is also included.

A natural gas distribution system for the reheat/ holding furnace, ladle and tundish heating, plant heating and miscellaneous service drops is included. A back up fuel oil system (#2 fuel oil) for the reheat furnace, including a short term oil storage tank, is also provided.

Oxygen will be distributed from a single storage tank (provided by others) to the arc furnace mezzanine and miscellaneous service drops.

2. Plant Equipment and Process Description

Prepared scrap delivered by truck to the melt shop will be stored in scrap bins prior to transfer by a magnet equipped 10t overhead crane directly to a single 8ft. diameter

Electric arc furnace fitted with water cooled panels and located on a 9ft. mezzanine. The furnace is powered by a 3MVA transformer and is capable of producing 4 ton heats in 3 hours tap to tap time.

Furnace fume emissions are contained by a hood collection system over the furnace and tapping spout. The fume is ducted to a reverse flow pressure type baghouse of 130,000 scfm capacity.

The arc furnace taps into a 6 ton capacity ladle which is suitably designed to provide a continuous supply of liquid steel to the tundish. The ladle sits on a ladle carriage which moves on rail tracks to the tundish of a horizontal casting machine of proprietary design. The tundish which is induction heated has a capacity of approximately 3000 lbs. of liquid steel. The casting machine is designed to operate continuously for approximately 24 hours with the liquid steel level in the tundish topped up from the ladle when required.

The casting machine has a withdrawal unit and pendulum type hydraulic shear in line, where the bars of 1½" to 2½" section are cut to approx. 10ft. lengths.

At this time it is not clear whether the cast bars can be rolled direct to finished product or if some form of

intermediate inspection/heat treatment/machining will be required. The accumulation of as cast bars during periods of mill down time can also be anticipated. These considerations require a process system with the ability to slow cool and subsequently reheat the as cast product. Consequently a reheating/holding furnace charged near the centre and with discharge from both ends is proposed. When direct rolling, bars entering the furnace from the casting machine run out table will be preheated to 1650°F prior to discharge into a 1100KW, 1000 HZ, 3 coil induction heating unit where they will be brought up to rolling temperature. When not direct rolling, bars entering the furnace from the casting machine run out table will be moved away from the mill through a slow cooling zone of the furnace with discharge to storage.

The reheat/holding furnace is designed to preheat cold bars to 1650°F at a rate of 2 tons per hour.

Following induction heating the bars are transferred to the mill pass line.

The rolling mill comprises four reversing mills arranged in two tandem configuration, each tandem consisting of one 14" horizontal and one 14" vertical mill. Roll face will be 28" and each mill will be driven by a 500 H.P.D.C.

reversing motor and gear drive. The mills will be positioned to the pass line by hydraulic shift.

It is anticipated that up to 14 passes will be required for the ½"-1" sections to be produced. Following rolling to section, the bars will be cut by flying shear to approximately 10ft. lengths and bundled for controlled cooling.

At this time, it has not been established whether the rolled product will be shipped direct off the mill or whether annealing and machining equipment will be required at the plant. An allowance has been made in the capital budget estimates for these facilities and adequate space has been provided in the mill building for their installation (as indicated in the layout drawing).

3. Buildings

The melting and casting facilities are housed in a 40 ft. x190ft.bay serviced by a 10t E.O.T. crane. Provision has been made in the layout for alloy storage and charging facilities and peripheral furnace equipment on the furnace mezzanine floor and for ladle and tundish repair and preheat facilities. A lean-to annex to the melt shop has been provided for refractory storage.

The rolling mill,heat treatment and finishing facilities are housed in a 50ft. x 295ft. bay serviced by a 5 ton E.O.T. crane. A combination maintenance and repair shop with roll storage and roll preparation facilities are also located in the bay. Provision has been made in the layout for the storage of in-process material and finished products.

2.3 MANNING SCHEDULES

Plant Manning Summary

	Days Only	Shift	Total
Salaried Employees	20	-	20
Hourly Paid Employees	7	49	56
Total	27	49	76

Plant Manning

(a) Salaried Employees

Plant Manager	- 1
Secretary/Receptionist	- 1
Melting Casting Foreman	- 1
Roller	- 1
Stock Clerk	- 1
Maintenance General Foreman	- 1
Purchasing Manager	- 1
Safety/Personnel Manager	- 1
Industrial Nurse	- 1
Clerk/Typist	- 1
Janitor	- 1
Accountant	- 1
Payroll/Billing Clerk	- 1
Accounts Receivable/Payable Clerk	- 1
Shipping/Finishing Foreman	- 1
Shipper	- 1
Sales Manager	- 1
Technical Salesman	- 1
Service Metallurgist	- 1
Clerk/Typist Shipping	- 1
Total	20

(b) Hourly Paid Employees

	Per Shift	3 Shifts	2 Shifts	Days Only
Melting (arc furnace)				
Lead Hand/First Helper	1	3		
2nd Helper	1	3		
Stocker	1	3		
Ladleman	1	3		
Casting (one Machine Operating)				
Machine Operator	1	3		
Helper	1	3		
Reheating and Rolling				
Stocker/Furnaceman				1
Millmen	2	6		1
Set up Man				1
Helper				1
Annealing and Grinding				
Furnace Operators	1	3		
Grinding Machine Operators	1	3		
Stocker				1
Maintenance				
Refractory Repairman	1		2	
Refractory Labour	1		2	
Casting Machine set up				1
Millwrights	1	3		
Electricians	1	3		
Roll Turning	1	3		

Quality Control					
Shift Chemist	1	3			
Lab Technician					1
Shift Technician	1	3			
Sub-Totals		45		4	
Totals			49		7

2.4 MISCELLANEOUS DEPARTMENTAL COSTS

Melt Shop Labour

Salaried Employees (1)	$42,000
Hourly Paid Employees (18)	360,000
	$402,000 or $63.81/ton of cast product

Rolling Mill Labour

Salaried Employees (5)	$122,000
Hourly Paid Employees (17)	340,000
	$462,000 or $98.30/ton of finished product

Maintenance Expenses

Salaried Employees (1)	$42,000
Hourly Paid Employees (14)	280,000
Repair & Maintenance Materials @ $5/ton	24,000
	$346,000

Allocation

55% Melt Shop	40% Rolling Mill	5% Admin.
$190,000 or $30.16/ton of cast product	$138,000 or $29.36/ton of finished product	$18,000

Quality Control Expenses

Hourly paid employees (7)	$140,000
Supplies	40,000
	$180,000

Allocation

67% Melt Shop	33% Rolling Mill
$120,000 or $19.05/ton of cast product	$60,000 or $12.77/ton of finished product

Plant Administration Cost

Salaries including benefits at 20%	$352,000
Provision for directors fees and expenses	10,000
Public relations	5,000
Travel and entertainment & auto rental	25,000
Advertising	10,000
Equipment Rentals	10,000
Auditing costs	10,000
Donations, subscriptions and dues	5,000
Legal & professional fees	20,000
Stationery and postage	5,000
Provision for doubtful accounts	20,000
Misc. supplies and services	10,000
Maintenance labour, supervision, supplies and tools	18,000
Personnel supplies and safety supplies	20,000
Water	10,000
Insurance	25,000
Taxes	100,000
Consulting fees	10,000
	$665,000

2.5 OPERATING COSTS

Operating costs have been prepared for the production of three tool steel grades - M2, M7, and T1 - with typical analysis tabulated below. A product mix comprising equal proportions of these three grades has been assumed in computing the mean operating cost and selling price for the tool steel bar stock operation.

TYPICAL CHEMICAL ANALYSES

Grade	Carbon	Chromium	Vanadium	Tungstem	Molybdenum
M2	0.85%	4.00%	2.00%	6.25%	5.00%
M7	1.00%	4.00%	2.00%	1.75%	8.75%
T1	0.70%	4.00%	1.00%	18.00%	-

ESTIMATED OPERATING COSTS FOR CONVERSION TO CAST BAR AND ROLLED BAR PRODUCTS - M2 Grade (2100 tons per year)

1. Per ton of Cast Bar

Yield scrap to cast bar 87.4%

Steel scrap 0.735 tons @ $100/ton	73.50
H.S.S. scrap 0.200 tons @ $ 2,675/ton	535.00
	608.50
Credit for Steel Plant returns (0.05 tons @ $2675/ton)	133.75
Net Scrap Cost	474.75
Additives and Alloys	$2377.10
Fluxes	4.80
	2856.65
Supervision and Labour	63.81
Electrodes	13.19
Power	13.32
Refractories	11.63
Oxygen	0.83
Fuel	1.35
Supplies & Outside Services	2.00
Slag Disposal (allowance)	1.20
Quality Control	19.05
Maintenance	30.16
Cast Bar Production Cost	$3013.19

2. Per Ton of Shipped Product (1566 tons per year)

Yield cast bar to finished product	75%
Cost of cast bars produced	$3013.19
Cost at 75% yield	4017.59
Credit for Mill Returns	
0.20 ton @ $2675.00	535.00
Net cast bar cost per ton of finished product	$3482.59
Supervision and Labour	98.30
Fuels and refractories	6.90
General Supplies	2.50
Rolls and Guides	6.50
Anneal and grind	10.00
Quality Control	12.77
Maintenance	29.36
Total cost per ton of finished product	$3648.92

ESTIMATED OPERATING COSTS FOR CONVERSION TO CAST BAR AND ROLLED BAR PRODUCTS - M7 Grade (2100 tons per year)

1. Per ton of Cast Bar

Yield scrap to cast bar 87.4%

Steel scrap 0.728 tons @ $100/ton	72.80
H.S.S. scrap 0.200 tons @ $2,030 /ton	406.00
	478.80
Credit for Steel Plant returns (0.05 tons @ $2,030/ton)	101.50
Net Scrap Cost	377.30
Additives and Alloys	$1756.50
Fluxes	4.80
	$2138.60
Supervision and Labour	63.81
Electrodes	13.19
Power	13.32
Refractories	11.63
Oxygen	0.83
Fuel	1.35
Supplies & Outside Services	2.00
Slag Disposal (allowance)	1.20
Quality Control	19.05
Maintenance	30.16
Cast Bar Production Cost	$2295.14

2. Per Ton of Shipped Product (1567 tons per year)

Yield cast bar to finished product	75%
Cost of cast bars produced	2295.14
Cost at 75% yield	3060.19
Credit for Mill Returns	
0.20 ton @ $2030.00	406.00
Net cast bar cost per ton of finished product	$2654.19
Supervision and Labour	98.30
Fuels and refractories	6.90
General Supplies	2.50
Rolls and Guides	6.50
Anneal and grind	10.00
Quality Control	12.77
Maintenance	29.36
Total cost per ton of finished product	$2820.52

ESTIMATED OPERATING COSTS FOR CONVERSION TO CAST BAR AND ROLLED BAR PRODUCTS - T1 Grade (2100 tons per year)

1. Per ton of Cast Bar

Yield scrap to cast bar 87.4%

Steel scrap 0.695 tons @ $100/ton	69.50
H.S.S. scrap 0.200 tons @ $ 4,850 /ton	970.00
	1039.50
Credit for Steel Plant returns (0.05 tons @ $4,850 $/ton)	242.50
Net Scrap Cost	797.00
Additives and Alloys	4432.10
Fluxes	4.80
	5233.90
Supervision and Labour	63.81
Electrodes	13.19
Power	13.32
Refractories	11.63
Oxygen	0.83
Fuel	1.35
Supplies & Outside Services	2.00
Slag Disposal (allowance)	1.20
Quality Control	19.05
Maintenance	30.16
Cast Bar Production Cost	$5390.44

2. Per Ton of Shipped Product (1567 tons per year)

Yield cast bar to finished product	75%
Cost of cast bars produced	5390.44
Cost at 75% yield	7187.25
Credit for Mill Returns	
0.20 ton @ $4,850.00	970.00
Net cast bar cost per ton of finished product	$6217.25
Supervision and Labour	98.30
Fuels and refractories	6.90
General Supplies	2.50
Rolls and Guides	6.50
Anneal and grind	10.00
Quality Control	12.77
Maintenance	29.36
Total cost per ton of finished product	$6383.58

2.6 CAPITAL COST ESTIMATE

CAPITAL BUDGET ESTIMATE SUMMARY

		$
1.	Site	228,000
2.	Utilities	2,770,000
3.	Melting & Casting	3,850,000
4.	Rolling & Finishing	6,612,000
5.	Ancillaries	364,000
6.	Spare Parts	333,000
7.	Engineering, Project Management & Other Professional Services	1,722,000
	Total	15,879,000

CAPITAL COST ESTIMATE

	$	$
1. Site		
1.1 Permits and Surveys	10,000	
1.2 Site Preparation	20,000	
1.3 Transportation & Site Work	136,000	
1.4 Storm Drainage	12,000	
1.5 Site Purchase - allowance	50,000	
TOTAL		228,000
2. Utilities		
2.1 Process Water System	925,000	
2.2 Potable Water	51,000	
2.3 Fuels and Oxygen	86,000	
2.4 Sanitary System	71,000	
2.5 Electrical Services	1,440,000	
2.6 Compressed Air	111,000	
2.7 Service Building - Pumps and Compressors	86,000	
Total		2,770,000
3. Melt Shop		
3.1 Scrap Handling	200,000	
3.2 Melting	1,597,000	
3.3 Additive & Refractory Systems	123,000	
3.4 Casting	725,000	
3.5 Air Pollution Control	782,000	
3.6 Melt Shop Crane	178,000	
3.7 Melt Shop Buildings	245,000	
Total		3,850,000

		$	$
4.	Rolling Mill		
	4.1 Reheating System	307,000	
	4.2 Rolling Mill	4,124,000	
	4.3 Product Handling & Finishing	587,000	
	4.4 Quality Control & Roll Shop	722,000	
	4.5 Mill Crane	129,000	
	4.6 Mill Building	743,000	
	TOTAL		6,612,000
5.	Ancillaries		
	5.1 Scale House & Track Scale	120,000	
	5.2 Maintenance & Stores Equipment	60,000	
	5.3 Main Office and Change House	184,000	
	TOTAL		364,000
6.	Spare Parts Allowance		
	5% of Equipment Cost		333,000
7.	Engineering, Project Management & Other Professional Services		
	12.5% of Capital Cost with Site Purchase and Spare Parts allowance excluded		1,722,000

PLANTS UNDER CONSIDERATION

SECTION 3 - Grinding ball production
- approximately 36,000 tons per year
  2½" to 4½" in diameter

3.1 PLANT PARAMETERS

Forging Stock cast directly to size

Ball size range 2½" to 4½"

Assume average ball size 3½"

(1) AT CASTING MACHINE

Forging stock for 3½" balls is 2½" round

Anticipated casting rate 2.2 tph/strand

Assume 95% availability at casting machines

Therefore, anticipated overall casting rate = 2.2 x 0.95

= 2.1 tph/strand

Have 5760 hrs./year available

Therefore, annual tonnage/strand = 5760 x 2.1 = 12,100 tons/strand

Assume have three casting machines available each single stranded (+1 machine on standby/repair).

Therefore, annual casting capability = 3 x 12,100 = 36,300 tons

(2) At Ball Forger and Rounder

Yield at ball forge - 98%

From 36,300 tons cast product will therefore produce 35,600 tons of grinding balls.

For 3½" average ball size, forge will operate either directly on material cast at 6.6 tons per hour from the three (3) casting machines or reheated stock at the ball forge operating rate of 12.2 tons per hour.

(3) At Melting Unit

Casting 36,300 tons /year of forging stock

Assume liquid metal/cast bar yield = 97%

Therefore require $\frac{36,300}{0.97}$ = 37,400 tons/year of liquid metal

Have 5760 hrs./year available

Anticipate melting efficiency (availability) = 90%

Therefore, available hours = 5760 x 0.9 = 5184 hours

Therefore, Melting rate required = $\frac{37,400}{5184}$ = 7.2 tph liquid metal

Assume 90 minute heat cycle

Therefore need $\frac{7.2}{60}$ x 90 = 10.8 ton heat size

3.2. PLANT DESCRIPTION (see Drawing MA004372 in the Appendix)

1. Site and Services

A 5 acre site of reasonable terrain has been anticipated with adequate power supply and water of sufficient quantity and suitable quality available at the site boundary.

The capital budget estimate anticipates that the plant will be serviced by a single 46kv line to a main switchyard where appropriate transformation and switching equipment for arc furnace power supply and plant distribution systems will be installed.

A combined recirculating process water system for both equipment and product cooling is provided. Equipment cooling water (arc furnace - including water cooled panels, transformer, casting machine moulds, induction heating units, etc.) together with contact water from the ball heat treatment operation will be fed to a primary settling pit. It will be pumped to a thickener/clarifier to further reduce scale levels and collected in a hot well. The process water will then be pumped over open evaporative type water cooling tower cells to a cool well from which it is recirculated through the system. Losses in the process water system, through evaporation,

blowdown etc. will be replaced by treated potable water. The pumping equipment for the system will be installed in a pumphouse, with the hot and cool wells also located in the building. Equipment for a plant compressed air system will also be installed in the pumphouse.

Plant potable water and sanitary systems are provided. A plant fire protection system supplied from the potable water system is also included.

A natural gas distribution system for the reheat/ holding furnace, ladle and tundish heating, plant heating and miscellaneous service drops is included. A back up fuel oil system (#2 fuel oil) for the reheat furnace, including a short term oil storage tank, is also provided.

Oxygen will be distributed from a single storage tank (provided by others) to the arc furnace mezzanine and miscellaneous service drops.

2. Plant Equipment and Process Description

Prepared scrap delivered by truck to the melt shop will be stored in scrap bins prior to transfer by a magnet equipped

20t overhead crane to a 250 cu.ft. capacity scrap bucket located on a automatic weigh scale. The scrap is then transferred via scrap bucket by the melt shop crane to a single 9ft. diameter electric arc furnace fitted with water cooled panels and located on a 21ft. mezzanine. The furnace is powered by a 13MVA transformer and is capable of producing approximately 11 ton heats in 90 minutes tap to tap time.

Furnace fume emissions are contained by direct evacuation through the furnace roof combined with a hood collection system over the furnace and tapping spout. The fume is ducted to a reverse flow pressure type baghouse of 150,000 scfm capacity.

The arc furnace taps onto a 20 ton capacity ladle which is suitably designed to provide a continuous supply of liquid steel to the tundishes. The ladle sits on a ladle carriage which moves on rail tracks over the tundishes of three horizontal casting machines of proprietary design. Tundish capacity is approximately 3000 lbs. of liquid steel. The machines are designed to operate continuously for approximately 24 hours with the liquid steel level in the tundish topped up from the ladle when required.

Each casting machine has a withdrawal unit and pendulum type hydraulic shear in line,where the bars of 1 3/4" to 3 1/4" section are cut to approx. 25 ft. lengths. They pass via runout tables and a cross transfer table to the entry of a gas fired holding/reheat furnace. Normal operating practice will be to direct charge the as-cast bars to the walking beam furnace for temperature equalisation and preheating to 1650°F. The bars will then be brought up to forging temperature by a 1100 KW, 1000 HZ, 3 coil induction heating unit located in line with a ball forging machine.

Laydown space is provided in the vicinity of the holding/reheat furnace to accommodate cast bars produced during periods of ball forge downtime. The furnace is designed to preheat these cold bars to 1650°F at a rate of 7 tons per hour with subsequent induction heating prior to ball forging during periods of melt shop down time or when periodically required.

Following induction heating to forging temperature the bars are fed into a ball forging machine of proprietary manufacture, nominally described as a 4" single action machine and capable of producing grinding balls in a size range of 1½" to 4". After forging the balls pass to a ball rounder which is used to improve concentricity and surface finish. The balls are then conveyed through a combination air and water

quench prior to a tempering operation to relieve the internal stresses set up during quenching
The balls are then conveyed to storage bins prior to magnet handling for truck shipment.

3. Buildings

The melting and casting facilities are housed in a 45ft. x 125ft. bay serviced by a 20t E.O.T. crane. Provision has been made in the layout for alloy storage and charging facilities and peripheral furnace equipment on the furnace mezzanine floor and for ladle and tundish repair and preheat facilities. A lean-to annex to the melt shop is provided for refractory storage.

The forge plant and finishing facilities from the exit of the casting machine to product storage and shipment are housed in a 65ft. x 275ft. bay serviced by a 5 ton E.O.T. crane. A combination electrical/mechanical repair and maintenance shop is located in an annex to the bay. Provision has been mad in the layout for the storage of in-process material and finished products.

3.3 MANNING SCHEDULES

Plant Manning Summary

	Days Only	Shift	Total
Salaried Employees	16	3	19
Hourly Paid Employees	8	52	60
Total	24	55	79

Plant Manning

(a) Salaried Employees

Plant Manager	- 1	
Secretary/Receptionist	- 1	
Shift Production Foremen	- 3	(1 per shift)
Maintenance General Foreman	- 1	
Metallurgist	- 1	
Purchasing Manager	- 1	
Safety/Personnel/Manager	- 1	
Industrial Nurse	- 1	
Clerk/Typists	- 2	
Janitor	- 1	
Accountant	- 1	
Payroll/Billing Clerk	- 1	
Accts./Payable/Receivable	- 1	
Sales Manager	- 1	
Salesman	- 1	
Clerk/Typist (Shipping)	- 1	
Total	19	

(b) Hourly Paid Employees

	Per Shift	3 Shift Operation	2 Shift Operation	Days Only
Raw Material Handling				
Crane Operator	1	3		
Labourer	1	3		
Melting (1 arc furnace)				
Lead Hand/First Helper	1	3		
2nd Helper	1	3		
Stocker	1	3		
Ladleman	1	3		
Casting (Three Machines Operating) and Reheating/Stocking				
Machine Operators	2	6		
Helper	1	3		
Reheat Furnace/Stocker	1	3		
Ball Forging (One Machine)				
Forge Operator	1	3		
Stocker/Shipper	1	3		
Crane Operator/Stocker	1	3		
Maintenance				
Refractory Repairman	1		2	
Refractory Labour/Helpers	1		2	
Casting M/C Tundish set up				1
Millwright	1	3		1
Electrician	1	3		1
Welder				2
Machinist				2
Quality Control				
Shift Chemist	1	3		
Lab Technician				1
Total		48	4	8
			52	

3.4 MISCELLANEOUS DEPARTMENTAL COSTS

Melt Shop Labour

Salaried Employees (1½)	$ 63,000
Hourly Paid Employees (30)	600,000
	$663,000

Ball Forging Labour

Salaried Employees (2½)	$ 78,000
Hourly Paid Employees (9)	180,000
	$258,000

Maintenance Expenses

Salaried Employees (1)	$ 42,000
Hourly Paid Employees (17)	340,000
Repair and maintenance materials @ 3$/ton (36,000 tons)	108,000
	$490,000

Allocation

50% Melt Shop	45% Ball Production	5% Admin.
$245,000	$220,000	$ 25,000

Quality Control Expenses

Salaried Employees (1)	$ 36,000
Hourly Paid Employees (4)	80,000
	$116,000

Allocation

60% Melt Shop	40% Ball Production
$70,000	$46,000

Plant Administration Cost

Salaries including benefits at 20%	$322,000
Provision for directors fees	10,000
Public relations	5,000
Travel, entertainment and auto rental	25,000
Advertising	10,000
Equipment rentals	10,000
Auditing costs	10,000
Donations, subscriptions and dues	5,000
Legal and Professional Fees	20,000
Stationery and Postage	5,000
Provision for doubtful accounts	15,000
Misc. supplies and service	10,000
Maint. Labour, supervision, supplies and tools	25,000
Personnel supplies and safety supplies	20,000
Water	10,000
Insurance	25,000
Taxes	100,000
Consulting Fees	10,000
	$637,000

3.5 OPERATING COSTS

Estimated Operating costs for Conversion to Cast Bar and Forged Ball Products

1. Per ton of cast bar (36,300 tons per year)

Yield scrap/cast bar 90.2%

Scrap 1.109 tons @ 100$/ton	$110.90
Less scrap credit (0.05 tons @ $ 90$/ton)	4.50
Net scrap cost	106.40
Additives & Alloys	10.54
Fluxes	3.43
	$120.37
Supervision and Labour	18.26
Electrodes	13.19
Power	13.32
Refractories	11.63
Oxygen	0.73
Fuel	1.31
Supplies & Outside Services	1.85
Slag Disposal (allowance)	1.00
Quality Control	1.93
Maintenance	6.75
Cast Bar Production Cost	$190.34

2. Per Ton of Forged Balls (35,600 tons per year)

Yield cast bar to finished balls = 98%

Cost of cast bars produced	$190.34
Cost at 98% yield	$194.22
Less scrap credit 0.01 ton @ 90$/ton	0.90
Net cast bar cost per ton of finished balls	$193.32
Supervision and Labour	7.25
Power, Fuels & Refractories	2.30
Tooling Costs	1.80
General Supplies	1.00
Heat Treatment	0.75
Quality Control	1.29
Maintenance	6.18
	$213.89

3.6 CAPITAL COST ESTIMATE

CAPITAL BUDGET ESTIMATE SUMMARY

		$
1.	Site	234,000
2.	Utilities	2,684,000
3.	Melting & Casting	6,613,000
4.	Ball Forging	3,111,000
5.	Ancillaries	364,000
6.	Spare Parts	360,000
7.	Engineering, Project Management & other Professional Services	1,301,000
	TOTAL	$14,667,000

Capital Cost Estimate

	$	$
1. Site		
1.1 Permits and Surveys	10,000	
1.2 Site Preparation	26,000	
1.3 Transporation and Site Work	136,000	
1.4 Storm Drainage	12,000	
1.5 Site Purchase - Allowance	50,000	
TOTAL		234,000
2. Utilities		
2.1 Process Water System	862,000	
2.2 Potable Water	51,000	
2.3 Fuels and Oxygen	172,000	
2.4 Sanitary System	71,000	
2.5 Electrical Services	1,331,000	
2.6 Compressed Air	111,000	
2.7 Service Building -pumps and compressors	86,000	
TOTAL		2,684,000
3. Melt Shop		
3.1 Scrap Handling	164,000	
3.2 Melting	1,718,000	
3.3 Additive & Refractory Systems	234,000	
3.4 Casting	2,157,000	
3.5 Air Pollution Control	1,728.000	
3.6 Melt Shop Crane	237,000	
3.7 Melt Shop Buildings	375,000	
TOTAL		6,613,000

		$	$
4.	Ball Forging		
	4.1 Reheating Systems	1,039,000	
	4.2 Ball Forging and, Rounding	1,096,000	
	4.3 Treatment and Storage	203,000	
	4.4 Quality Control	54,000	
	4.5 Forge Shop Crane	132,000	
	4.6 Forge Shop Building	587,000	
	TOTAL		3,111,000
5.	Ancillaries		
	5.1 Weighing Facilities	120,000	
	5.2 Maintenance & Stores Equipment	60,000	
	5.3 Main Office and Change House	184,000	
	TOTAL		364,000
6.	Spare Parts Allowance		
	5% of Equipment Cost		360,000
7.	Engineering, Project Management & Other Professional Services		
	10% of Capital Cost with site purchase cost and spare parts allowance excluded		1,301,000

PLANTS UNDER CONSIDERATION

SECTION 4 - Grinding ball production
- approximately 17,000 tons per year
1½" to 2½" diameter

4.1 PLANT PARAMETERS

Forging Stock cast directly to size

Ball size range from 1½" to 2½"

Assume average ball size 2"

(1) AT CASTING MACHINE

Forging stock for 2" balls is 1 3/8" round

Anticipated casting rate 0.6 tph/strand

Assume 90% availability at casting machine

Anticipated overall casting rate = 0.6 x 0.90
= 0.5 tph/strand

Have 5760 hrs/year available
Annual tonnage/strand = 5760 x 0.5
= 2880 tons

Assume have three casting machines available each double stranded (+1 machine on standby/repair)

Annual casting capability = 3 x 2 x 2880 = 17,300 tons

(2) AT BALL FORGER AND ROUNDER

Yield at ball forge - 98%

from 17,300 tons of cast product will therefore, produce 17,000 tons of grinding balls

For 2 " average ball size, forge will operate either directly on material cast at 3.0 tons per hour from the 3 x 2 strand casting machines or reheated stock at the ball forge operating rate of 4.2 tons per hour.

(3) AT MELTING UNIT

Casting 17,300 tons/year of forging stock

Assume liquid metal/cast bar yield = 97%

Require $\frac{17,300}{0.97}$ = 17,800 tons /year of liquid metal

Have 5760 hrs./year available

Anticipate melting efficiency (availability) = 90%

Available hours = 5760 x 0.9 = 5184 hours

Melting rate required = $\frac{17,800}{5,184}$ = 3.43 tph liquid metal

Assume 90 minute heat cycle

Need $\frac{3.43 \times 90}{60}$ = 5.1 ton heat size

4.3 PLANT DESCRIPTION (see Drawing MA004373 in the Appendix)

1. Site and Services

A 5 acre site of reasonable terrain has been anticipated with adequate power supply and water of sufficient quantity and suitable quality available at the site boundary.

The capital budget estimate anticipates that the plant will be serviced by a single 46kv line to a main switchyard where appropriate transformation and switching equipment for arc furnace power supply and plant distribution systems will be installed.

A combined recirculating process water system for both equipment and product cooling is provided. Equipment cooling water (arc furnace - including water cooled panels, transformer, casting machine moulds, induction heating units, etc.) together with contact water from the ball heat treatment operation will be fed to a primary settling pit. It will be pumped to a thickener/clarifier to further reduce scale levels and collected in a hot well. The process water will then be pumped over open evaporative type water cooling tower cells to a cool

well from which it is recirculated through the system. Losses in the process water system, through evaporation, blowdown etc. will be replaced by treated potable water. the pumping equipment for the system will be installed in a pumphouse, with the hot and cool wells also located in the building. Equipment for the plant compressed air system is also installed in the pumphouse.

Plant potable water and sanitary systems are provided. A plant fire protection system supplied from the potable water system is also included.

A natural gas distribution system for ladle and tundish heating, plant heating and miscellaneous service drops is included.

Oxygen will be distributed from a single storage tank (provided by others) to the arc furnace mezzanine and miscellaneous service drops.

2. Plant Equipment and Process Description

Prepared scrap delivered by truck to the melt shop will be stored in scrap bins prior to transfer by a magnet equipped 10t overhead crane directly to a 8 ft. diameter electric arc furnace fitted with water cooled panels and

located on a 20ft. mezzanine. The furnace is powered by a 7.5MVA transformer and is capable of producing 5 ton heats in 90 minutes tap to tap time.

Furnace fume emissions are contained by direct evacuation through the furnace roof combined with a hood collection system over the furnace and tapping spout. The fume is ducted to a reverse flow pressure type baghouse of 130,000 scfm capacity.

The arc furnace taps into a 10 ton capacity ladle which is suitably designed to provide a continuous supply of liquid metal to the tundishes. The ladle sits on a ladle carriage which moves on rail tracks over the tundishes of three double stranded horizontal casting machines of proprietary design. Tundish capacity is approximately 3000 lbs. of liquid steel. The machines are designed to operate continuously for approximately 24 hours with the liquid steel level in the tundish topped up from the ladle when required.

Each strand of each casting machine has a withdrawal unit and pendulum type hydraulic shear in line, where the bars of 1" to 1 3/4" section are cut to approx. 25 ft. lengths. They pass via runout tables and a cross transfer table to the entry to an induction heating unit. Normal operating practice will be to direct

charge the as-cast bars to the walking beam furnace for temperature equalisation and preheating to 1650°F. The bars will then be brought up to rolling temperature by the 1200KW, 3000 HZ, 5 coil induction heating unit located in line with a ball forging machine.

Laydown space is provided in the vicinity of the holding/reheat furnace to accommodate cast bars produced during periods of ball forge downtime. The induction heating unit is sized to heat these cold bars to forging temperature at a rate of 3 tons per hour during periods of melt shop down time or when periodically required.

Following induction heating to forging temperature the bars are fed into a ball forging machine of proprietary manufacture, nominally described as a 2" double action machine and capable of producing grinding balls in a size range of 1" to 2½". After forging the balls pass to a ball rounder which is used to improve concentricity and surface finish. They are then conveyed through a combination air and water quench before being fed to storage bins prior to magnet handling for truck shipment.

3. Buildings

The melting and casting facilities are housed in a 45ft. x 135ft. bay serviced by a 10t E.O.T. crane. Provision has been made in the layout for alloy storage and

charging facilities, peripheral furnace equipment on the furnace mezzanine floor and for ladle and tundish repair and preheat facilities. A lean-to annex to the melt shop has been provided for refractory storage.

The forge plant and finishing facilities from the exit of the casting machine to product storage and shipment are housed in a 60ft. x 225ft. bay serviced by a 5 ton E.O.T. crane. A combination electrical/mechanical repair and maintenance shop is located in an annex to the bay. Provision has been made in the layout for the storage of in-process material and finished products.

4.3 MANNING SCHEDULES

Plant Manning Summary

	Days Only	Shift	Total
Salaried Employees	16	3	19
Hourly Paid Employees	8	49	57
Total	24	52	76

Plant Manning

(a) Salaried Employees

Plant Manager	- 1	
Secretary/Receptionist	- 1	
Shift Production Foremen	- 3	(1 per shift)
Maintenance General Foreman	- 1	
Metallurgist	- 1	
Purchasing Manager	- 1	
Safety/Personnel/Manager	- 1	
Industrial Nurse	- 1	
Clerk/Typists	- 2	
Janitor	- 1	
Accountant	- 1	
Payroll/Billing Clerk	- 1	
Accts./Payable/Receivable	- 1	
Sales Manager	- 1	
Salesman	- 1	
Clerk/Typist (Shipping)	- 1	
Total	19	

(b) Hourly Paid Employees

	Per Shift	3 Shift Operation	2 Shift Operation	Days Only
Raw Material Handling				
Crane Operator	1	3		
Labourer	1	3		
Melting (1 arc furnace)				
Lead Hand/First Helper	1	3		
2nd Helper	1	3		
Stocker	1	3		
Ladleman	1	3		
Casting (Three Machines Operating)				
Machine Operators	2	6		
Helper	1	3		
Ball Forging (One Machine)				
Forge Operator	1	3		
Stocker/Shipper	1	3		
Crane Operator/Stocker	1	3		
Maintenance				
Refractory Repairman	1		2	
Refractory Labour/Helpers	1		2	
Casting M/C Tundish set up				1
Millwright	1	3		1
Electrician	1	3		1
Welder				2
Machinist				2
Quality Control				
Shift Chemist	1	3		
Lab Technician				1
Total		45	4	8
			49	

4.4 MISCELLANEOUS DEPARTMENTAL COSTS

Melt Shop Labour

Salaried Employees (1½)	$ 63,000
Hourly Paid Employees (30)	600,000
	$663,000

Ball Forging Labour

Salaried Employees (2½)	$ 78,000
Hourly Paid Employees (6)	120,000
	198,000

Maintenance Expenses

Salaried Employees (1)	$ 42,000
Hourly Paid Employees (17)	340,000
Repair and maintenance materials @ 3$/ton (36,000 tons)	108,000
	$490,000

Allocation

50% Melt Shop	45% Ball Production	5% Admin.
$245,000	$220,000	$ 25,000

Quality Control Expenses

Salaried Employees (1)	$ 36,000
Hourly Paid Employees (4)	80,000
	$116,000

Allocation

60% Melt Shop	40% Ball Production
$70,000	$46,000

Plant Administration Cost

Salaries including benefits at 20%	$322,000
Provision for directors fees	10,000
Public relations	5,000
Travel, entertainment and auto rental	25,000
Advertising	10,000
Equipment rentals	10,000
Auditing costs	10,000
Donations, subscriptions and dues	5,000
Legal and Professional Fees	20,000
Stationery and postage	5,000
Provision for doubtful accounts	15,000
Misc. supplies and service	10,000
Maint. Labour, supervision, supplies and tools	25,000
Personnel supplies and safety supplies	20,000
Water	10,000
Insurance	25,000
Taxes	100,000
Consulting Fees	10,000

4.5 OPERATING COSTS

Estimated Operating costs for Conversion to Cast Bar and Forged Ball Products

1. Per ton cast bar (17,300 tons per year)

Yield scrap/cast bar 90.2%

Scrap 1.109 tons @ 100$/ton	$110.90
Less scrap credit (0.05 tons @ 90$/ton)	4.50
Net scrap cost	106.40
Additives & Alloys	13.11
Fluxes	3.43
	$122.94
Supervision and Labour	38.32
Electrodes	13.19
Power	13.32
Refractories	11.63
Oxygen	0.73
Fuel	1.31
Supplies & Outside Services	1.85
Slag Disposal (allowance)	1.00
Quality Control	4.05
Maintenance	14.16
Cast Bar Production Cost	$222.50

2. Per Ton of Forged Ball (17,000 tons per year)

Yield cast bar to finished balls = 98%

Cost of cast bars produced	$222.50
Cost at 98% yield	$227.04
Less scrap credit	
0.01 ton @ 90$/ton	0.90
Net cast bar cost per ton of finished balls	$226.14
Supervision and Labour	11.65
Power, Fuels & Refractories	3.85
Tooling Costs	4.10
General Supplies	1.00
Quality Control	2.70
Maintenance	12.94
	$262.38

4.6 CAPITAL COST ESTIMATE

CAPITAL BUDGET ESTIMATE SUMMARY

		$
1.	Site	232,000
2.	Utilities	2,440,000
3.	Melting & Casting	6,142,000
4.	Ball Forging	1,757,000
5.	Ancillaries	364,000
6.	Spare Parts	297,000
7.	Engineering, Project Management & Other Professional Services	1,089,000
	TOTAL	12,321,000

CAPITAL COST ESTIMATE

	$	$
1. Site		
1.1 Permits & surveys	10,000	
1.2 Site Preparation	24,000	
1.3 Transportation & Site Work	136,000	
1.4 Storm Drainage	12,000	
1.5 Site Purchase - allowance	50,000	
TOTAL		232,000
2. Utilities		
2.1 Process Water System	773,000	
2.2 Potable Water	51,000	
2.3 Fuels and Oxygen	86,000	
2.4 Sanitary System	71,000	
2.5 Electrical Services	1,262,000	
2.6 Compressed Air	111,000	
2.7 Service Buildings - Pumps and Compressor	86,000	
TOTAL		2,440,000
3. Melt Shop		
3.1 Scrap Handling	160,000	
3.2 Melting	1,356,000	
3.3 Additive & Refractory Systems	197,000	
3.4 Casting	2,442,000	
3.5 Air Pollution Control	1,448,000	
3.6 Melt Shop Crane	180,000	
3.7 Melt Shop Buildings	359,000	
TOTAL		6,142,000

		$	$
4.	Ball Forging		
	4.1 Reheating System	207,000	
	4.2 Ball Forging, Rounding & Storage	834,000	
	4.3 Quality Control	54,000	
	4.4 Forge Shop Crane	134,000	
	4.5 Forge Shop Building	528,000	
	TOTAL		1,757,000
5.	Ancillaries		
	5.1 Weighing Facilities	120,000	
	5.2 Maintenance & Stores Equipment	60,000	
	5.3 Main Office and Change House	184,000	
	TOTAL		364,000
6.	Spare Parts Allowance		
	5% of equipment cost		297,000
7.	Engineering, Project Management & other Professional Services		
	10% of Capital Cost with site purchase & spare parts allowance excluded		1,089,000

APPENDIX 1

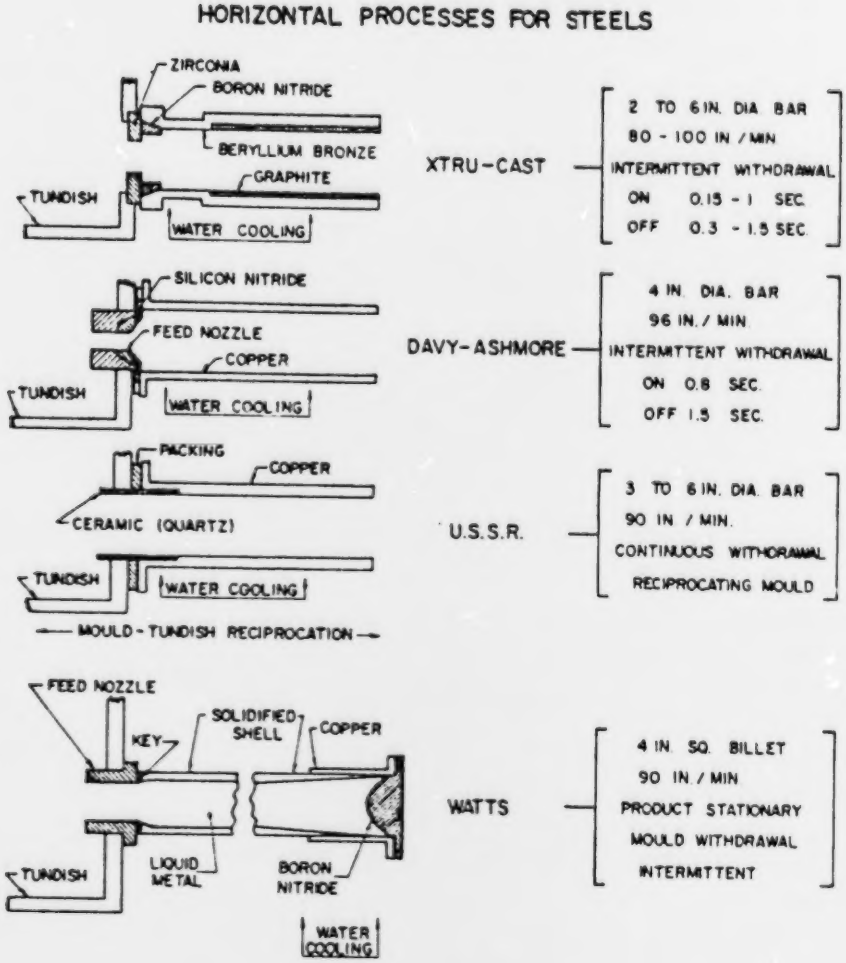
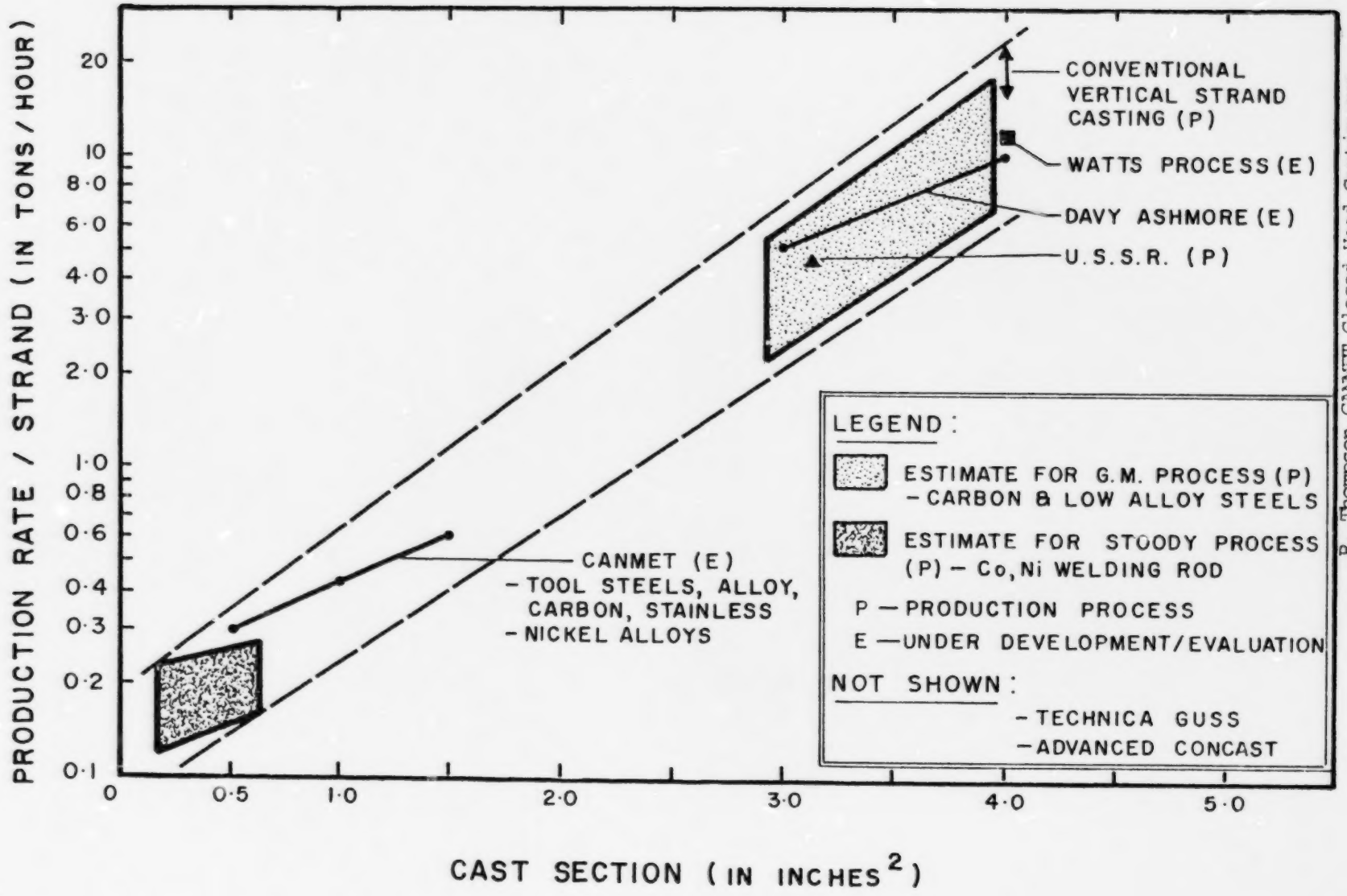


Fig. 1. Detail of mould/tundish designs for a number of horizontal continuous casting processes for steel.

R. Thompson
CANMET
A Micromill for
Strand Cast Steel
September 1977



R. Thompson CANMET Closed Head Continuous Casting Workshop Ottawa March 1979.

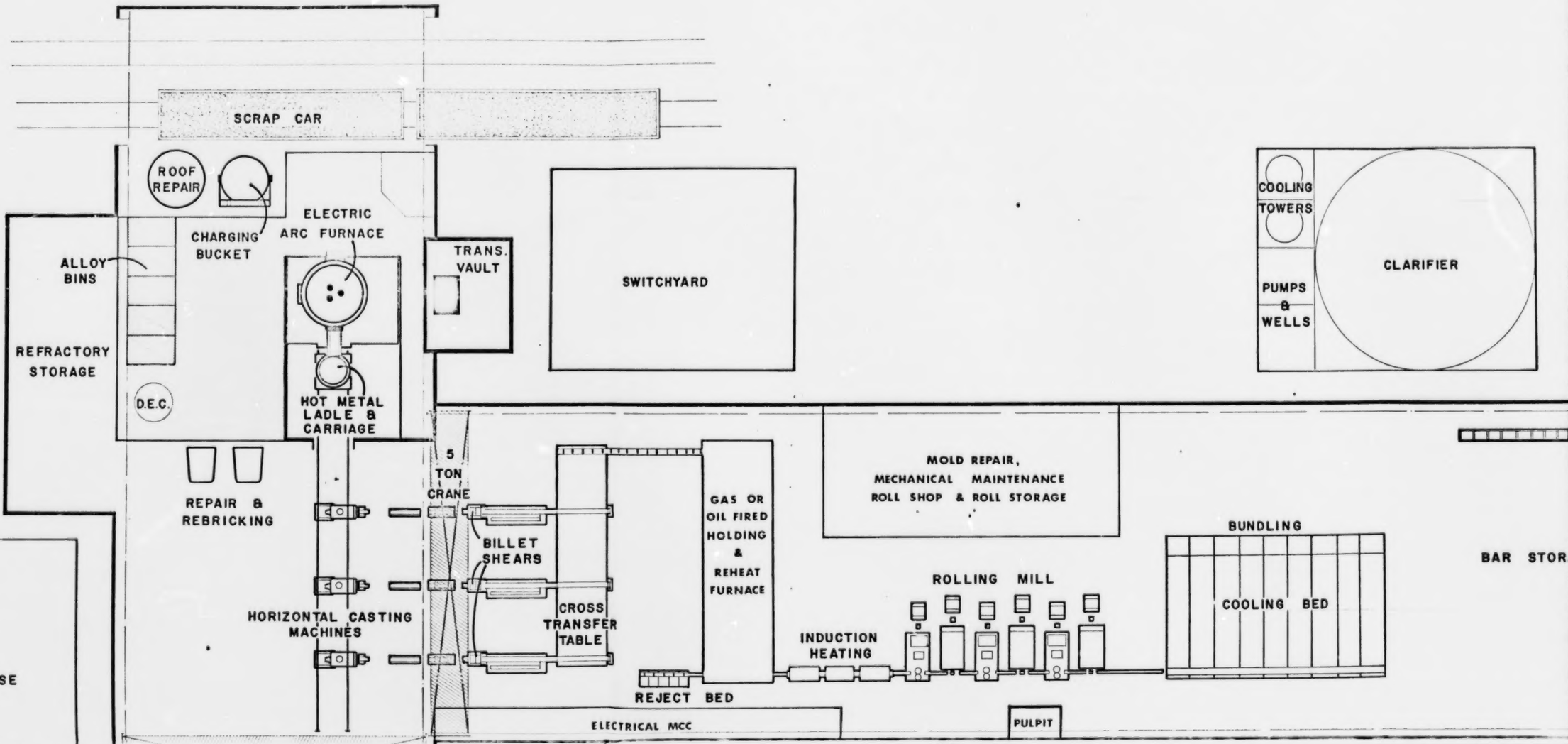
FIG 2

METAL - CERAMIC MOLD SYSTEMS FOR HORIZONTAL CASTING

A | B | C | D | E | F | G | H | J

DO NOT SCALE — IF IN DOUBT ASK

INCHES



J K L

REFERENCES

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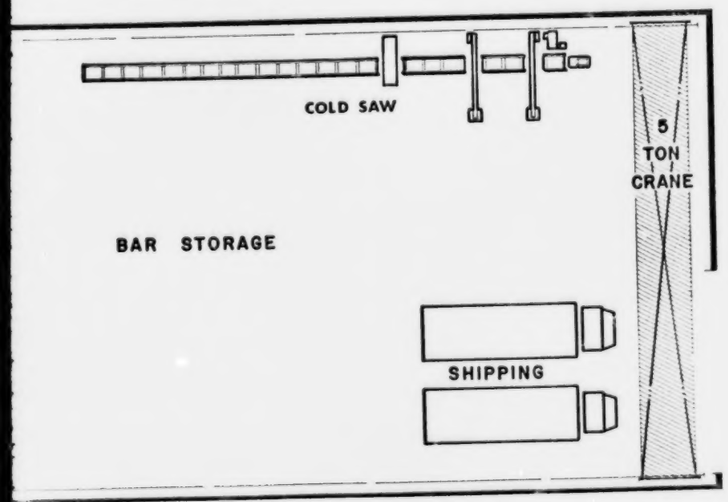
8 7 6 5 4



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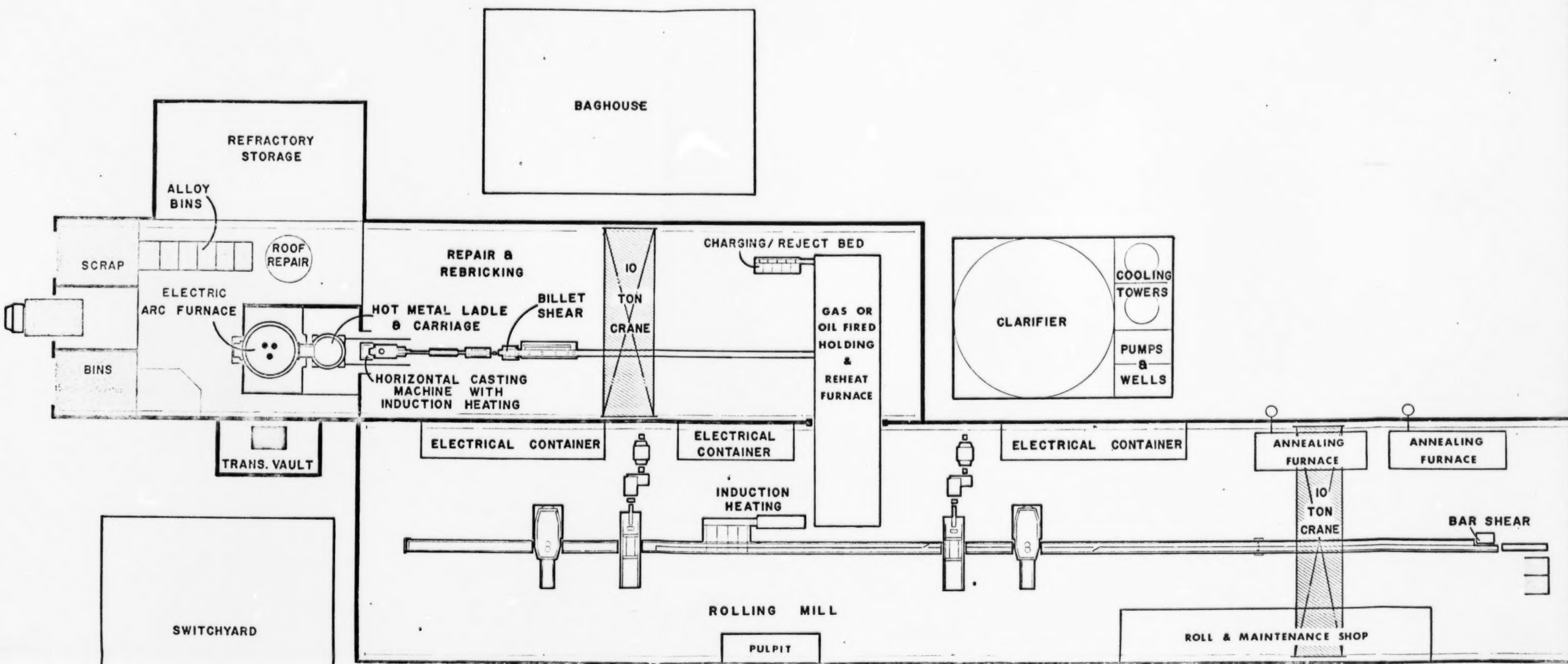

H J K L

INCHES CM

REFERENCES

DWG. No	TITLE

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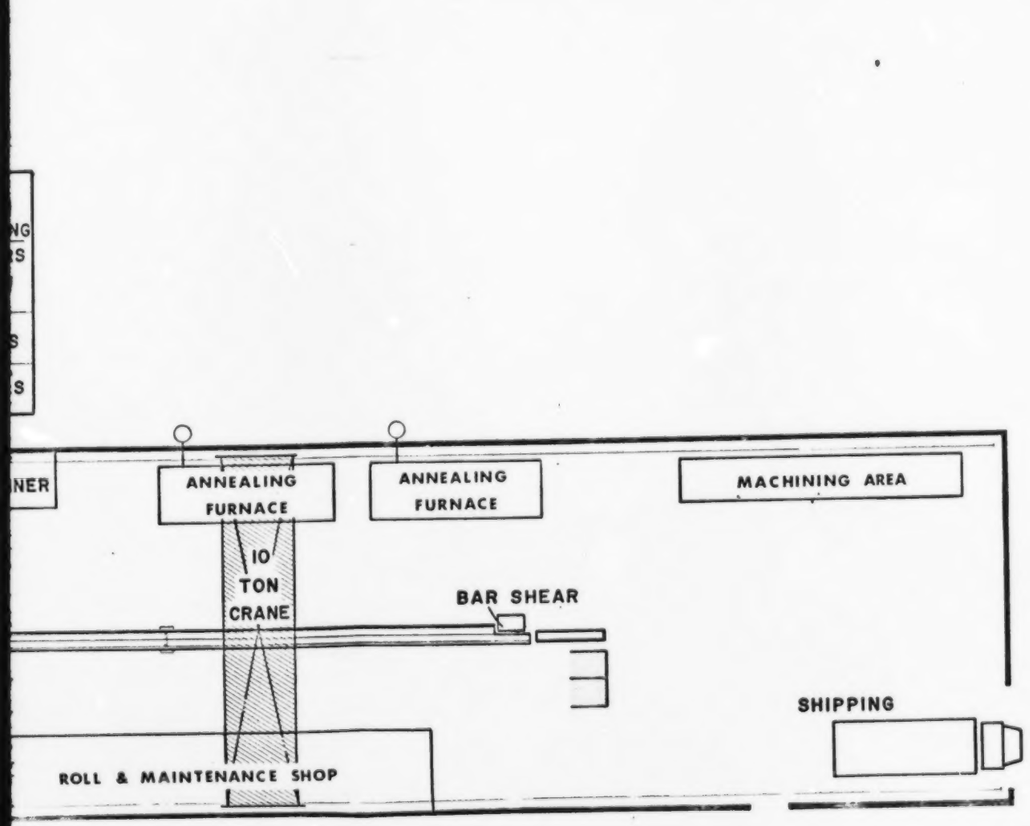


BAGHOUSE

HORIZONTAL CASTING MACHINES

35/10 TON CRANE

TRANSFER TABLE

REJECT BED

INDUCTION HEATING

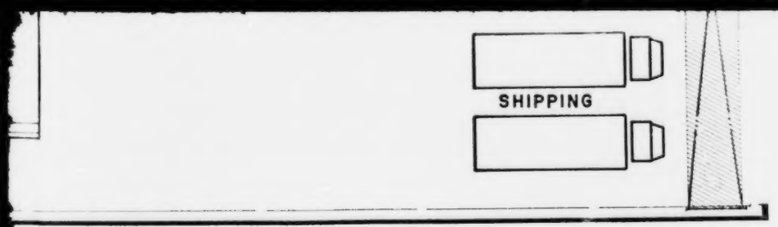
ELECTRICAL MCC

PULPIT

OFFICES

REVISION	DATE	NO.	DR.	REVISION	DATE	NO.	DR.	REVISION	DATE
						1	L.D.	REDRAWN	9/8/73

A B C D E F G H J



4

3

2

1

KEY PLAN

STRUCTURAL TOLERANCES ± 1/16"

FERRCO ENGINEERING LIMITED
WHITBY, ONTARIO, CANADA

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FORGING STOCK PLANT GENERAL ARRANGEMENT (71,000 T.P.Y.)

DES	DR	DATE	CLIENT DWG NO
H.S.	L.D.	SEPT. '79	
CHK	APP	SCALE 1" = 1'-0"	

FERRCO DWG NO. MA004370 REV 1

J K L

SWITCHYARD

INDUCTION HEATING

ROLLING MILL

PULPIT

10 TON CRANE

BAR SHEAR

ROLL & MAINTENANCE SHOP

OFFICES

REVISION	DATE	NO. DR.	REVISION	DATE	NO. DR.	REVISION	DATE
					I L.D	REDRAWN	9/8/78

A B C D E F G H J

BAR SHEAR

SHIPPING

OP

4

3

2

1

J

K

L

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TOOL STEEL PLANT
GENERAL ARRANGEMENT
(5,000 T.P.Y.)

DES	DR	DATE	CLIENT DWG NO
H.S.	L.D.	SEPT.'79	
CHK	APP	SCALE 1"=1'-0"	

FERRCO DWG NO MA004371 REV 1

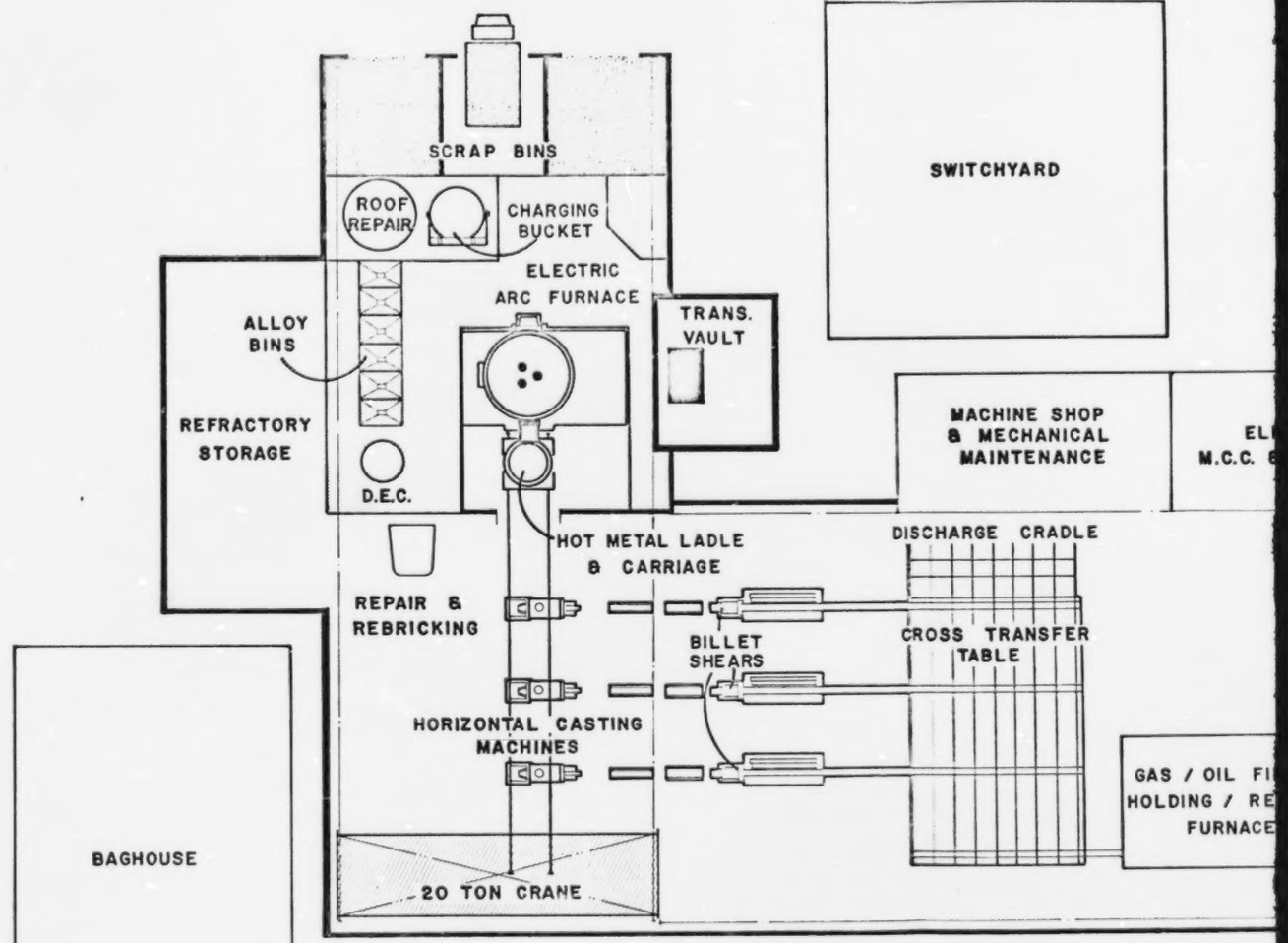
KEY PLAN

STRUCTURAL TOLERANCES ± 1/16"

A | B | C | D | E

DO NOT SCALE — IF IN DOUBT ASK

8



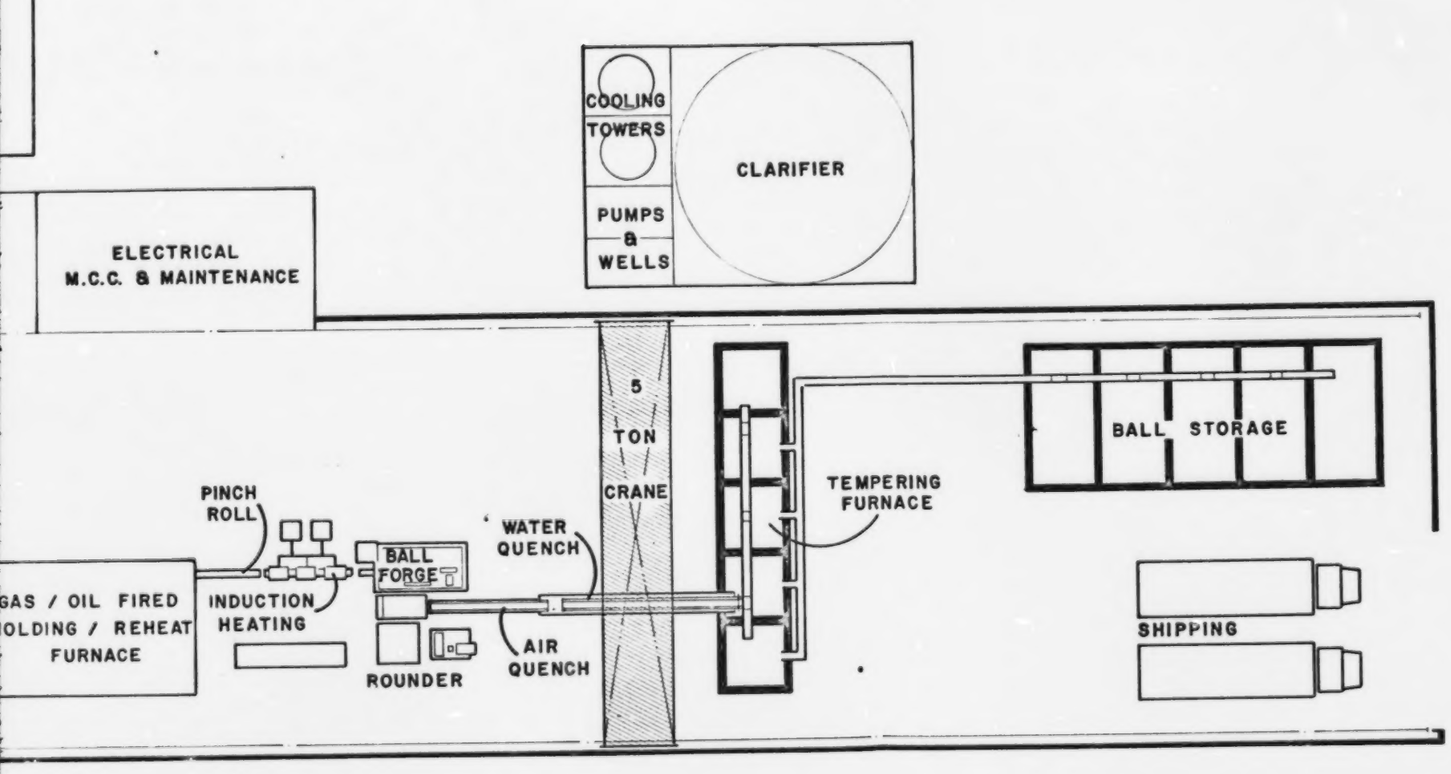
F G H J K L

INCHES

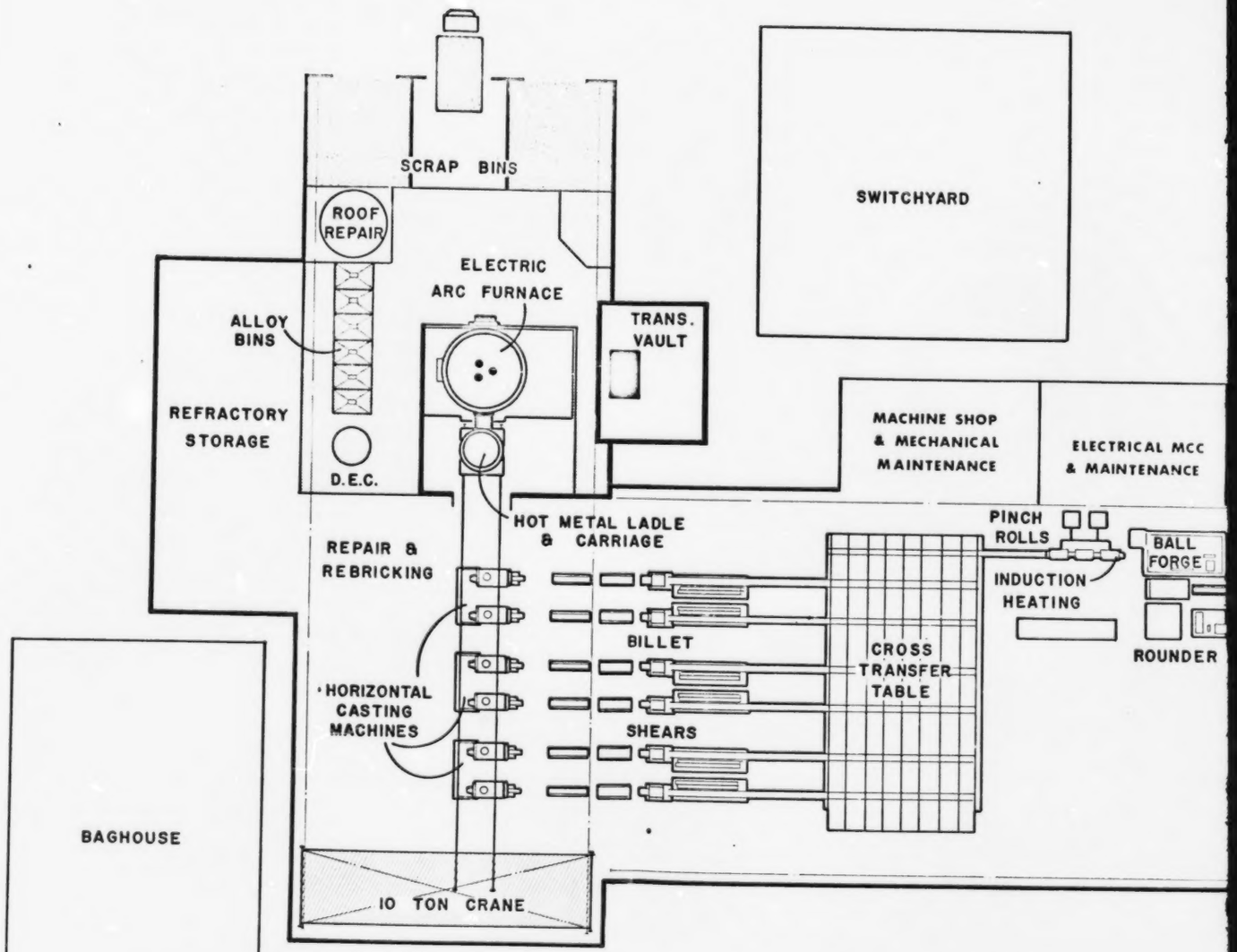
CM

REFERENCES	
DWG. NO.	TITLE

8 7 6 5 4



DO NOT SCALE — IF IN DOUBT ASK



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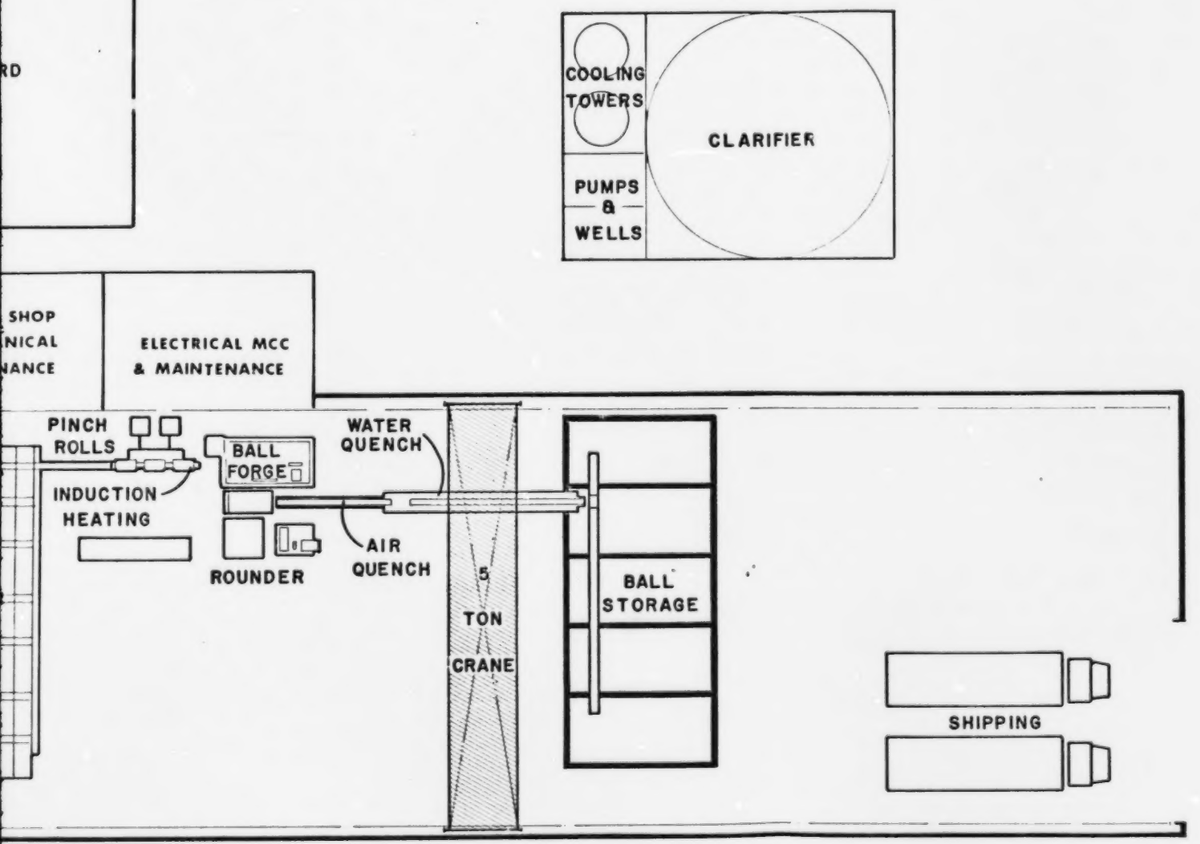
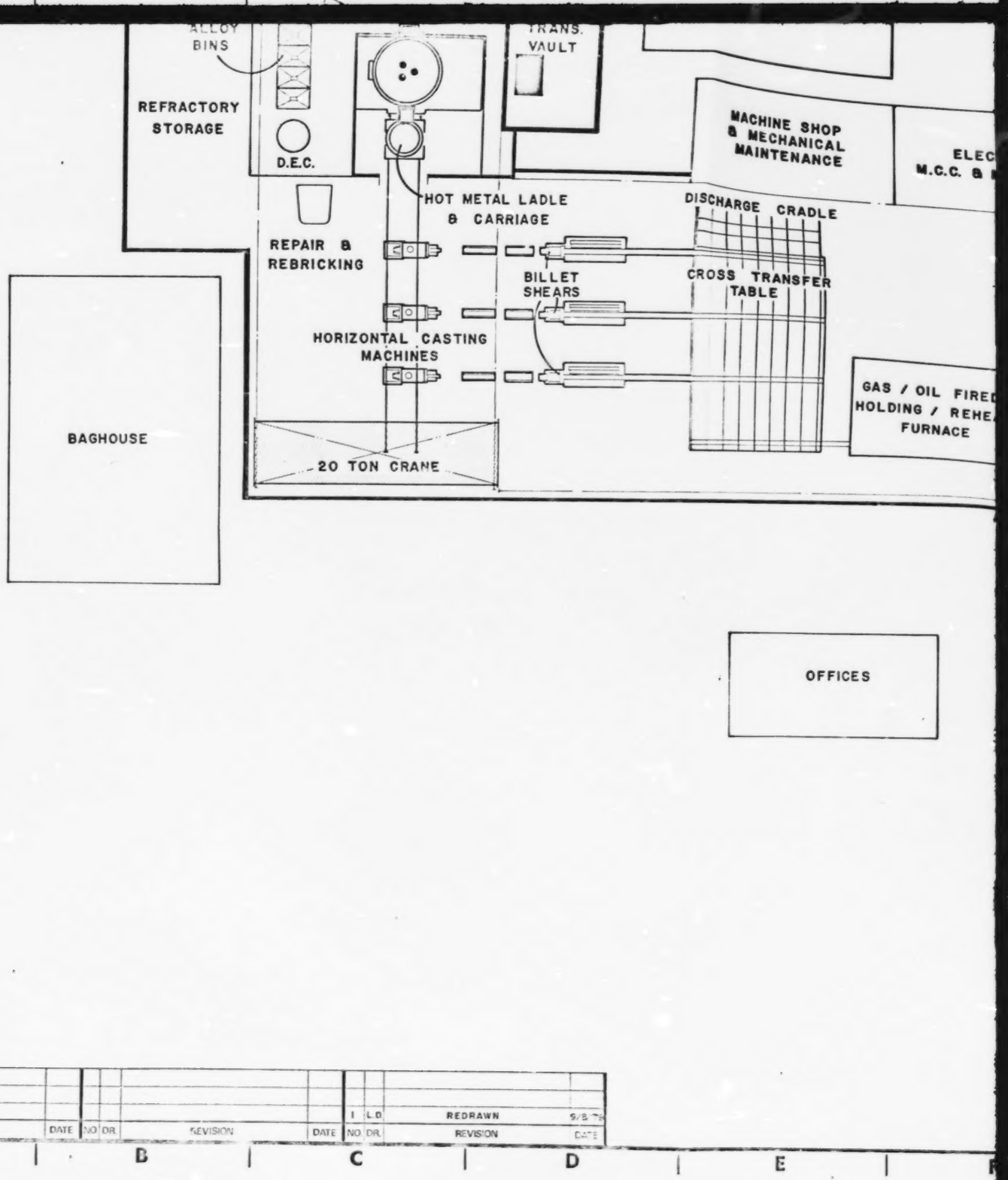
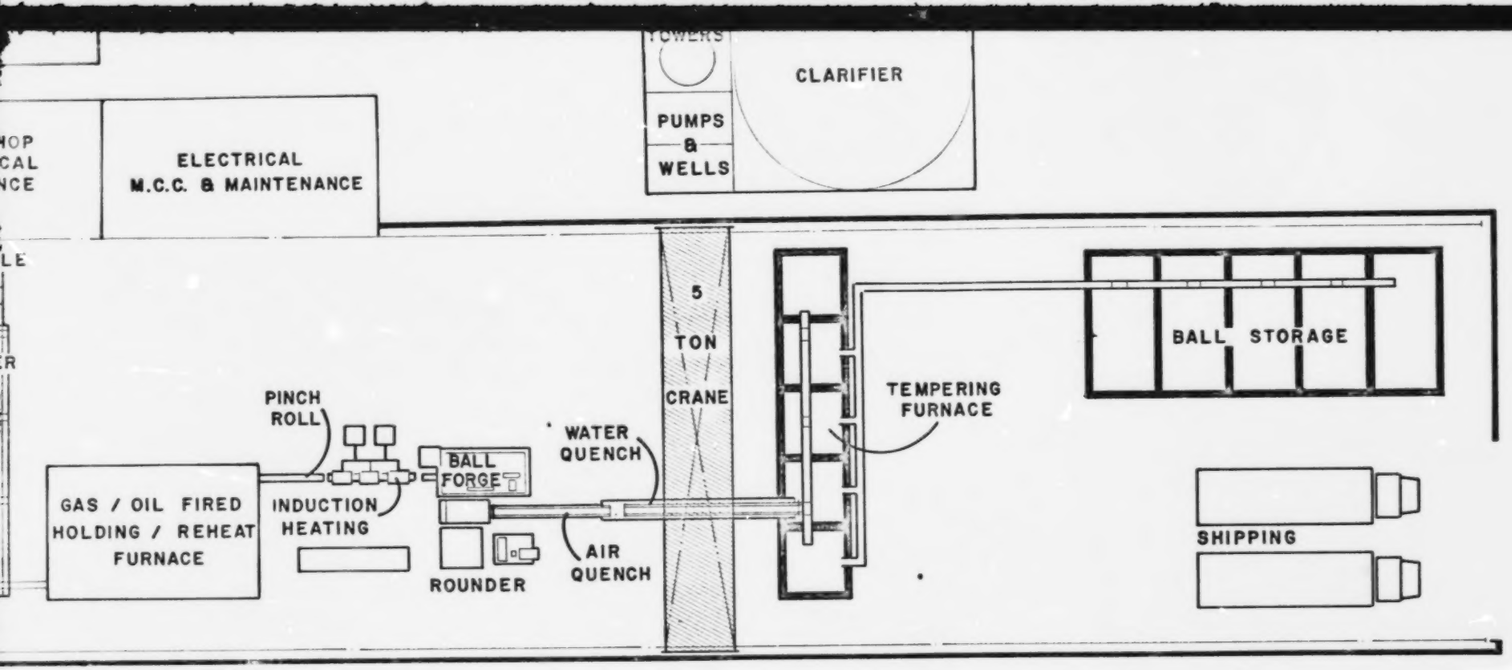
DWG NO	TITLE





REVISION	DATE	NO	DR.	REVISION	DATE	NO	DR.	REVISION	DATE
						1	L.D.	REDRAWN	9/8.78

A B C D E F



KEY PLAN

STRUCTURAL TOLERANCES ± 1/16"

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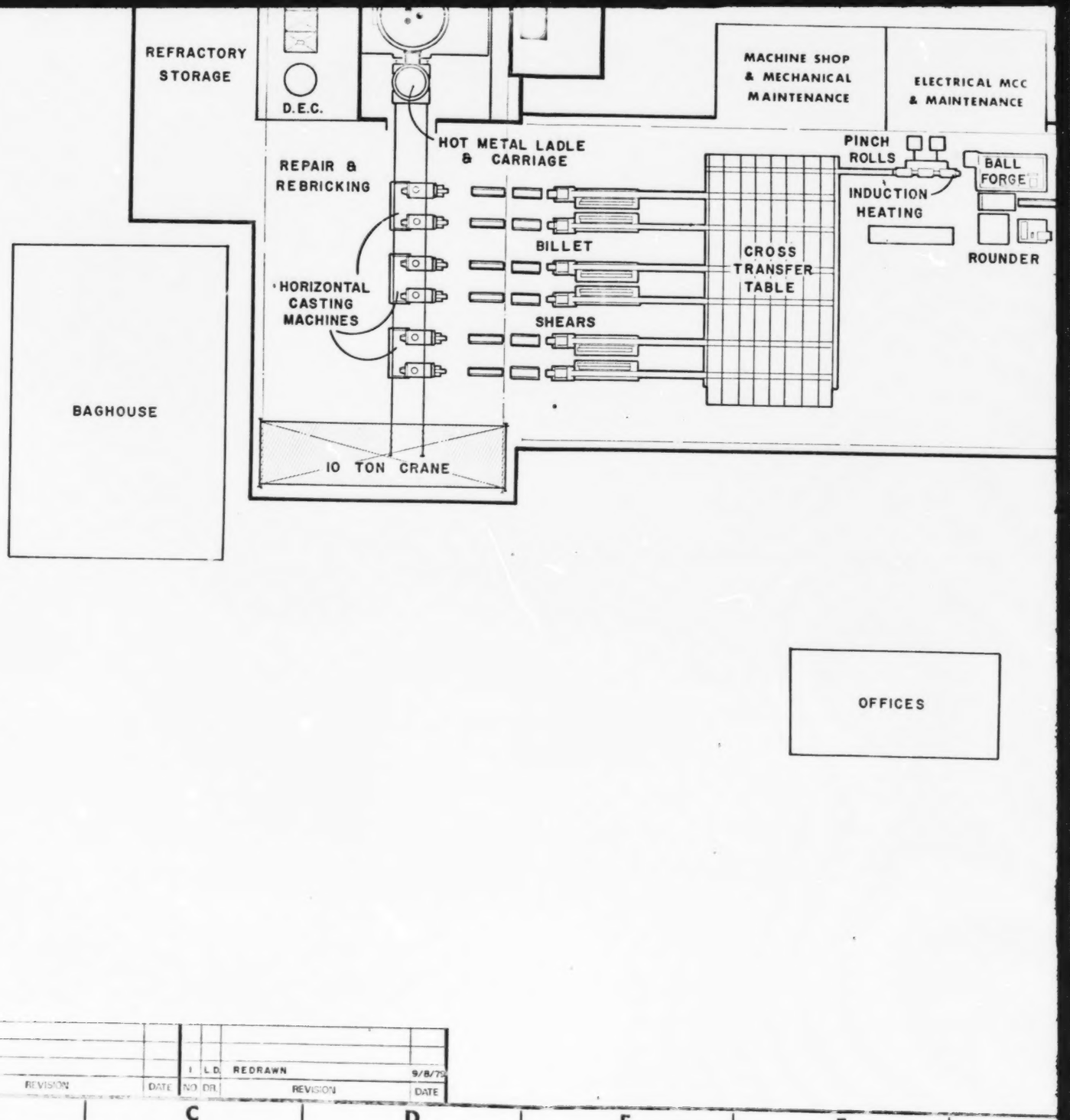
LARGE GRINDING BALL PLANT GENERAL ARRANGEMENT (36,000 T.P.Y.)

DES	DR	DATE	CLIENT DWG NO
H.S.	L.D.	SEPT. '79	
CHK	APP	SCALE 1" = 1'-0"	

FERRCO DWG NO: MA004372 REV: 1

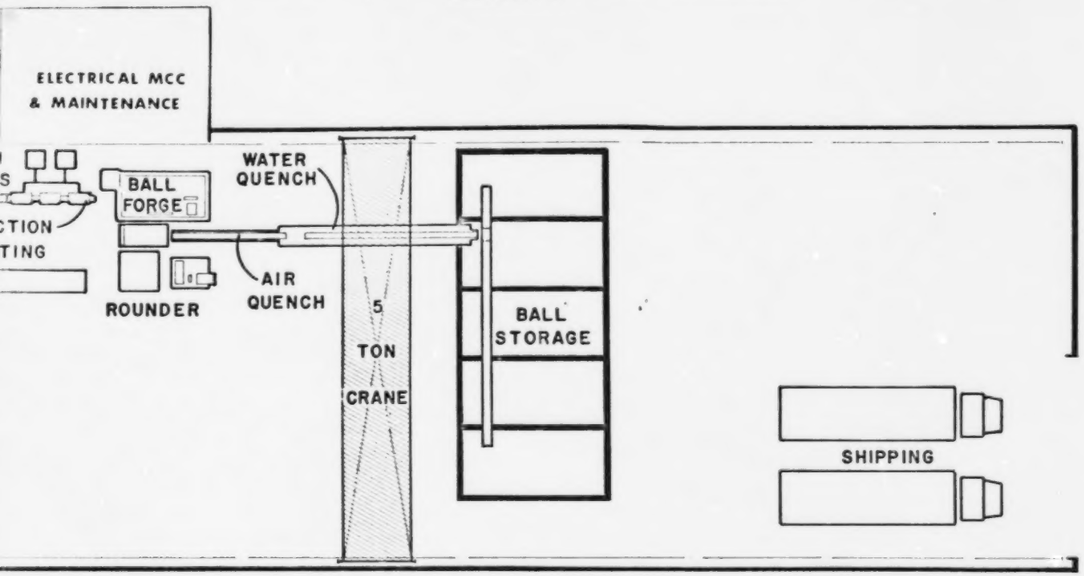
5 4 3 2 1

F G H J K L



REVISION	DATE	NO	DR.	REVISION	DATE	NO	DR.	REVISION	DATE
						1	L.D.	REDRAWN	9/8/79

A B C D E F G



FICES

KEY PLAN

STRUCTURAL TOLERANCES ± 1/16"

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SMALL GRINDING BALL PLANT
GENERAL ARRANGEMENT
(17,000 T.P.Y.)

DES	DR	DATE	CLIENT DWG NO
H.S.	L.D.	SEPT '79	
CHK	APP	SCALE	
		1" = 1'-0"	

FERRCO DWG NO: MA004373 REV: 1

5 4 3 2 1

G H J K L